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CONTENTS

	Page		Page
The Prague meetings of the International Geodetic and Geophysical Union and its Meteorological Section. Herbert H. Kimball.....	387	NOTES AND ABSTRACTS:	
Performance in long-range weather forecasting. C. F. Brooks.....	390	Note regarding previous use of correlation periodogram by Clayton. Dinsmore Alter.....	413
Berlage on east-monsoon forecasting for Java. (2 figs.) A. J. Henry.....	395	Nile flood studies. F. Grolssmayr.....	413
Recent contributions to hygrometry. S. P. Fergusson.....	398	India seems assured of another satisfactory monsoon. Repr.....	414
Das Klima als Wettergesamtheit (climate as totality of the weather). (2 figs.) E. S. Federov. Translated and summarised by E. S. Nichols.....	401	September weather in the British Isles. Repr.....	414
Frequencies of weather types at San Jose, Calif. (2 figs.) E. S. Nichols.....	403	Weather in various parts of the world as affecting trade. Repr.....	414
The St. Louis tornado of September 29, 1927. M. W. Hayes. (13 figs.).....	405	Meteorological summary for Brazil, August, 1927. Jo de Sampaio Ferraz.....	414
Meteorological conditions over the sea in the eastern Mediterranean. (1 fig.) H. Meredith.....	407	BIBLIOGRAPHY.....	414
Ice forecasting by means of the weather. (2 figs.) U. S. Coast Guard Bulletin.....	409	SOLAR OBSERVATIONS.....	418
Outline of "The climatic regions of eastern North America." (2 figs.) W. Van Royen.....	410	AEROLOGICAL OBSERVATIONS.....	420
Corrected solar constant values for Montezuma. C. G. Abbot.....	420	WEATHER IN THE UNITED STATES.....	422
		WEATHER ON THE ATLANTIC AND PACIFIC OCEANS.....	428
		CLIMATOLOGICAL TABLES.....	432
		CHARTS I-XIII.	



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CORRECTIONS

APRIL, 1927, REVIEW:

Page 207, *Florida Peninsula* section, the temperature departure for *Miami*, printed as "41.6" should be "+ 1.6."

JULY, 1927, REVIEW:

Page 315, the title of the article should be "The climatic regions of eastern North America."

Same article, third paragraph, fourth line, before "conditions" insert "actual."

Page 319, first column, second paragraph, in the equation the letters "A" and "B" should be set over near the left margin. In the fourth paragraph the *equality sign* between "E" and "e" should be a *minus sign*.

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

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SEPTEMBER, 1927

CLOSED Nov. 3, 1927
ISSUED Nov. 26, 1927

THE PRAGUE MEETINGS OF THE INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION AND ITS METEOROLOGICAL SECTION

By HERBERT H. KIMBALL

Delegate from the American Geophysical Union

The Third General Assembly of the International Geodetic and Geophysical Union was held at Prague, Czechoslovakia, September 3 to 10, 1927. The first general assembly was held in Rome in May, 1922; the second in Madrid in October, 1924. Brief accounts of these two earlier meetings will be found in the MONTHLY WEATHER REVIEW for September, 1922, 50: 488, and November, 1924, 52: 533-536, respectively.

These general assemblies are made up of delegates from national unions of the countries affiliated with the International Research Council. In the case of the United States the delegates are, in general, named from the membership of the American Geophysical Union by the National Academy of Sciences and the National Research Council. The following were the delegates named for the third general assembly:

Dr. Louis A. Bauer, director, department of terrestrial magnetism of the Carnegie Institution of Washington;

Dr. William Bowie, chief, division of geodesy, United States Coast and Geodetic Survey;

Commander A. B. Cook, United States Navy;

Dr. J. H. Dellinger, senior physicist, radio section, United States Bureau of Standards;

Commander N. H. Heck, chief, division of terrestrial magnetism and seismology, United States Coast and Geodetic Survey;

Dr. Herbert H. Kimball, meteorologist, in charge solar radiation section, United States Weather Bureau;

Mr. W. D. Lambert, mathematician, division of geodesy, United States Coast and Geodetic Survey;

Dr. R. A. Millikan, director, California Institute of Technology, Pasadena, Calif.;

Dr. Harry Fielding Reid, professor of dynamic geology, Johns Hopkins University;

Guest of the union:

Prof. L. C. Graton, department of geology, Harvard University.

The wives and other members of families of delegates increased the number in the official party from the United States to 20 persons. It was a source of regret that Doctor Millikan was not able to reach Prague.

In the absence of Doctor Washington, chairman of the American Geophysical Union, Doctor Reid was selected by the delegates to act as their chairman.

The official opening of the general conference occurred on the morning of September 3 in the chamber of the House of Parliament. In the regretted absence of President Masaryk, of the Czechoslovakian Republic, on

account of illness, President Lallemand, of the union, presided, and also responded to speeches of welcome by national and city officials and the president of the Geodetic and Geophysical Committee of Czechoslovakia.

Following these ceremonies there was a short plenary session of the union at which the general secretary presented his report. It covered the period from April 1, 1924, to March 31, 1927. On the latter date 30 countries were affiliated in the union.

During this period there had been received from all sources, including the balance brought forward, 901,948.20 francs.¹ There had been disbursed 618,021 francs, leaving a balance of 283,927 francs.

The principal disbursements were through the sections of the union, as follows:

	Francs
Section of geodesy.....	205,010.00
Section of seismology.....	81,120.00
Section of meteorology.....	88,071.00
Section of terrestrial magnetism.....	81,699.40
Section of oceanography.....	70,205.00
Section of volcanology.....	59,591.00
Section of hydrology.....	6,000.00

The section of scientific hydrology received funds amounting to 30,000 francs from sources outside of the general funds of the union. These latter are received from the Governments of the 30 affiliated countries, the annual subscriptions varying from 20,800 francs for eight of the larger countries, including the United States, to 2,600 francs for small countries. The number of votes to which a country is entitled in either the plenary meetings or the meetings of a section depends upon the amount of its contribution, the maximum for any country being six votes.

The election of a president of the union, which was scheduled for this meeting, was postponed until the closing plenary meeting.

Delegates from the American Geophysical Union are accredited to the international union as a whole, and are free to participate in any of the section meetings. As a matter of fact, since meetings of all the sections are held at the same hours, delegates confine themselves almost exclusively to the meetings of the section dealing with their special branch of science. The writer was therefore in attendance upon the meetings of the meteorological section only.

Beginning with the session on the afternoon of September 3 and ending with that on the morning of September 10, the section held eight sessions. The first, presided over by the vice president, General Delcambre, received certain reports. At the second session, on Monday morning, September 5, the president, Sir Napier Shaw, reported on the work done by the bureau of the section during the three years that had elapsed since

¹ The approximate value of a franc is 3.94 cents

the last (Madrid) meeting. This embraced the publication of the procès-verbaux of the Madrid meeting in 1924, including an annexe on radiation in relation to meteorology, which contained data that was worthy of a wider distribution than the procès-verbaux has received. The delegates were therefore asked to designate libraries in their countries that should receive the publications of the section.

With reference to the appropriation of £400 for the purchase of pyrheliometers, three had been purchased at a total cost of £130.579. One was sent to the Apia Observatory, Samoa, a second to Spitzbergen, and a third was placed in the hands of M. Jaumotte, of Brussels, where it is now held for test before installing it in the Belgian Congo.

Four photometers, constructed after designs by Doctor Richardson, for measuring the albedo of different surfaces, have been obtained at a total cost of £40.2. One of these was on exhibition at the meeting of the section, and one has since reached the United States Weather Bureau. The instrument is designed primarily for use on airplanes.

Copies of the specimen volume of upper-air observations for the year 1923 were exhibited. The printed edition is 500 copies and the cost is £2 per copy. The work is a monument to the sagacity and untiring energy of the president of the Commission for the Exploration of the Upper Air, Sir Napier Shaw. The meteorological section of the union has contributed to the work by an appropriation of £500.

Each volume is in four parts, as follows:

Part 1 contains the *resolutions* that guided the commission in its preparation of the publication, definitions of units employed, and a list of the stations furnishing upper-air data.

Part 2 contains synoptic charts for the international days on which aerological data were obtained.

Part 3 contains the tabulated data.

Part 4 the indicator diagrams.

An effort is to be made to dispose of the edition of this first volume through subscriptions by institutions and individuals who are interested in aerological work. Volumes of data for more recent years will soon follow until finally it is hoped that the time elapsing between observing and publishing will be reduced to a minimum.

Other subjects treated in the report of the bureau include "A common unitary system for all the sciences comprised within the union," atmospheric dust, simplification of the calendar, and meteorological observations of the Pacific Ocean.

General Delcambre reported with reference to statements received in response to a resolution adopted at Madrid requesting the different weather services to report upon the scientific principles underlying their methods of forecasting. His comment was to the effect that more was said about the data employed than about the science involved. Most services base their forecasts on the movements of HIGHS and LOWS and the characteristic weather accompanying them.

On September 6 most of the time of both morning and afternoon sessions was devoted to solar radiation.

After the report of the chairman of the commission on solar radiation, with a supplemental report from Richardson on his special photometer, representatives of each country were called upon to state what was being done in their country in solar radiation. The resolutions of the American Union calling for arrangements whereby pyrheliometers in all countries may be brought into accord with some known pyrheliometric scale, and for the adoption

of standard methods of measuring and tabulating radiation intensity, were adopted. The existing radiation commission, with enlarged membership, was charged with carrying out the provisions of the resolutions, and also with preparing printed instructions for observers, and with testing and recommending standard glass screens for dividing the solar spectrum into sections. In this work the commission of the union is to cooperate as far as possible with the solar radiation commission of the International Meteorological Committee.

There were no sessions of the sections on September 7, the day being devoted to excursions to museums, art galleries, scientific institutions, and ancient and modern monuments in and about Prague.

On the morning of the 8th the section voted to purchase 25 copies of the published upper-air data for each of the next three years.

At the afternoon session it was reported that the weather charts of the North Atlantic, the preparation of which was authorized at the Madrid meetings, were not yet completed. It was voted to continue the allotment of £500, to extend the maps to cover the North Pacific Ocean, and that the data used should be for 1927 instead of for 1923.

At the sessions on September 9 a variety of subjects were under discussion, including the simplification of the calendar.

The terms of the two vice presidents and the secretary having expired, and as the secretary declined reelection, Captain Wehrle, of France, was elected secretary, and Dr. V. Bjerkness, of Norway, and Eredia, of Italy, were elected vice presidents.

On Saturday morning, September 10, the minutes of the meetings were read, corrected, and approved, as were also 22 resolutions that had been adopted at the sessions.

The final plenary meeting of the union was held on the afternoon of the 10th, at which time President Lallemand was unanimously elected to succeed himself for another term, and funds were allocated to carry on the work of the different sections.

Invitations were received from the delegates of both Sweden and Portugal to hold the next general assembly of the union in their country. In view of the fact that the bureau of the union had been authorized to ascertain if it would be agreeable to the International Astronomical Union to have the general assemblies of the two unions held in the same year and at places not greatly separated, it was voted to leave the selection of the time and place for holding the next general assembly to the Bureau of the Union. It was the general opinion that Stockholm would be the place.

This brought to a close what was by common consent considered the most important meeting yet held by the union. The attendance was large. While the printed list of delegates has not been received, an authoritative estimate places the number at 165.

The attendance at the meetings of the meteorological section was uniformly good, the subjects under discussion were important, and thanks to the skillful guidance of the chairman, Sir Napier Shaw, the discussions were interesting and enlightening.

The 22 resolutions that were adopted follow. They sum up the work done by the section at the meetings and what has been planned for the future.

Resolutions adopted by the meteorological section of the International Geodetic and Geophysical Union at Prague, September 3-10, 1927:

1

The section approves the report presented by the *Observatoire Météorologique National* of France on the inquiry relative to the scientific methods of weather forecasting applied by the central bureaus of the different countries. That institution is requested to deliver the publication which it has kindly undertaken as soon as possible before the next general assembly.

2

The section subscribes for 25 copies of the sample volume by the Commission on the High Atmosphere for the three years following 1923 at a rate not to exceed £3 per copy.

3

The assembly requests persons who publish memoirs in a language other than French, English, or German to add a résumé in one of these languages or in an artificial international language such as Esperanto or Ido.

4

In consideration of the progress accomplished by the network of observational stations in the Pacific Ocean the section considers it necessary that the experiment of publishing (in conformity with Resolution No. 26 of the Assembly of Madrid, which relates only to the Atlantic Ocean) daily synoptic charts be completed by extending them to include the entire Northern Hemisphere for the months of August, September, and October, 1927. The section urgently requests the central bureaus of the different countries to assist the editor in this undertaking by furnishing him the necessary data duly verified and in the form that will be proposed by him.

5

The section of meteorology compliments Professor Hanzlik on the important work that he has done, and expresses the desire that it may be completed with the information from other countries as yet not received. There is expressed the desire to see this report published, with the probable aid of the section of hydrology, in the proceedings of the section of meteorology.

6

The section calls the attention of geophysicists to the advantages of using, where practicable, geodynamic height in calculations and tables.

7

The section notes with satisfaction that the volume of tables of observations in the high atmosphere contains results at stations in tropical regions and in the Southern Hemisphere, especially sounding observations of wind in the high atmosphere and later of temperature at Hong Kong, sounding observations of wind in the high atmosphere at Colombo and D-wa in Ceylon, at seven stations in Brazil, at Pretoria, South Africa, on Willis Island, off the northeastern coast of Australia, and at Apia, in the South Pacific.

The section requests that the bureau of the union transmit a copy of this resolution to the proper authorities in the countries interested.

8

The section approves the proposal of M. Eredia with reference to the usefulness of considering what meteorological data are indispensable in indicating synthetically the climatological character of a given locality and requests M. Eredia to present a complete report on this matter at the next assembly.

9

The institutions that will receive Doctor Richardson's photometer are given permission to improve the same, provided they always undertake to make and publish the standardization of the instrument reconstructed.

10

The institutions that will receive the photometer are asked to publish in their own countries the results of the observations that they make and to report to the section of meteorology.

11

In view of the actinometric research by Professor Vološin in Czechoslovakia, the section of meteorology recommends this research to the Czechoslovakian institutions.

The section of meteorology of the International Geodetic and Geophysical Union is keenly interested in the results obtained by Doctor Pollak, privatdocent in the German University at Prague, in the elaboration of observational material from 150 European stations extending over a period of 10 years.

The section hopes that the work will be carried on and extended to other regions with the support of the State Statistical Service of the Republic of Czechoslovakia.

13

The section desires that copies of the minutes of the meeting, including papers presented, be placed in the greatest measure possible at the disposal of meteorological investigators and that a list of those to whom copies should be sent be prepared by the national committees.

The section requests that the bureau of the union combine the lists prepared by the national committees and make arrangement for the distribution of the minutes.

14

The section approves the appointment of a commission to consider the question of relations between the section of meteorology of the International Geodetic and Geophysical Union and the International Meteorological Committee. (See resolution adopted at Utrecht.)

The commission consists of: Sir Napier Shaw, president; General Delcambre, Professor Van Everdingen, Sir Gilbert Walker, and Doctor Hesselberg.

15

The section has a lively interest in the proposal relative to the preparation of daily synoptic charts of the South Pacific Ocean. It is of the opinion that an effort should be made to extend the scope of the charts and to have them include all of the Southern Hemisphere for the months chosen for the specimen volume of charts of the Northern Hemisphere and ultimately to publish the charts for this period. The section names a commission, Sir Napier Shaw, president; Andrew Thomson (Samoa), Doctor Kitson (New Zealand), R. G. K. Lempfert, and representatives of the meteorological services of Argentina, Brazil, and Chile, which will be charged with putting this resolution into effect.

The section authorizes the president to set apart the sum of £100 sterling, if it is available, for the expenses of preparation and publication.

16

The section joins with the American Geophysical Union in expressing its great pleasure and satisfaction in the purpose of the Smithsonian Institution and the National Geographic Society to maintain stations for a period of at least four years in North America, South America, and Southwest Africa.

17

The Astrophysical Observatory of the Smithsonian Institution is requested to publish as early as practicable the observations of these stations for all of the period during which they function.

18

The section of meteorology of the International Geodetic and Geophysical Union authorizes its commission for solar radiation—
(a) To encourage by all possible means the maintenance of an international network of pyrheliometric stations for measuring the intensity of solar energy.

(b) To include in this network as many high-level stations as possible.

(c) To make provision that at the high-level stations especially careful attention be given to the measurement of ultra-violet radiation and the ozone content of the atmosphere.

19

The above-named commission is authorized to cooperate with the commission for solar radiation of the International Meteorological Committee in arranging for the intercomparison of sub-standard pyrheliometers in use in the different countries, in preparing a program and practical instructions to be recommended for the daily observations, and in securing the prompt publication of monthly summaries of results.

Messrs. Kimball (chairman), Ångström, Gorczyński, Simpson, Platania, Maurain, Fabry, Mercanton, Sverdrup, Messegueur, Hurst, Thomson, Hunt, Dobson, Normand, Stewart, Dedeant, Patterson, and Vološin were named as members of this commission.

M. Delcambre signified his willingness to take charge of the printing of the instructions.

20

The bureau of the section is authorized and requested to draw up a report on the various practices of the different sciences comprised within the International Geodetic and Geophysical Union with regard to units of measurement and to invite the cooperation of the bureaus of the other sections of the union, with the ultimate object of a common unitary system for all the sciences comprised within the union.

21

The section approves the appointment of a commission to consider the question of the use of geopotential in the geophysical sciences as the vertical coordinate in the representation of the position of a point with reference to the earth for the purposes of geodynamic problems.

The commission representing the different sections of the union is constituted as follows: Seismology, Oddone; meteorology,

22

Shaw; oceanography, Martin Knudson; geodesy, Bulloni and Norland; vulcanology, Tanakadate; magnetism, Chapman; and hydrology, Wallen.

In view of the increased importance of the application of meteorological statistics of the weather to the problems of agriculture, public health, and other aspects of public economics, the bureau of the section is authorized to ask the International Conference of Directors of Meteorological Réseaux to receive a deputation of the section at a meeting of the directors in 1929 (which may be regarded as a jubilee celebration of the International Meteorological Congress at Rome) in order to urge the consideration of a more scientific grouping of meteorological statistics than the customary one by calendar months of arbitrary and unequal length.

And, further, upon receipt of a favorable reply, the directors of the bureau are authorized to arrange the deputation on behalf of the section.

PERFORMANCE IN LONG-RANGE WEATHER FORECASTING¹

By CHARLES F. BROOKS

[Clark University, Worcester, Mass., August 18, 1927]

SYNOPSIS

Long-range forecasts are so much desired that any number of unqualified persons issue them without regard for criteria of performance. Among what might be called "fake" forecasts are the almanac, astrological, pseudosolar, and "mathematical" sorts, many of them calamity howls. The "prediction" of climatic normals, forecasts from phenomena on certain dates and from the behavior or aspects of certain animals or plants also belong in this category.

To be of value a forecast must be specific, limited as to place and time, and it must have a probability of more than chance verification. Furthermore, the economic consequences of failures, both in the long run and in a small sequence of years, must be reckoned. A forecast that will not hit the mark four times out of five, or at least once out of every three in succession, can not be of much value, though some claim that a forecast verified only three times out of five would be useful. The uncertainties of meteorological relationships on which any long-range forecasts can now be based are generally too great to permit reputable meteorologists to forecast on expectations of less than 75 or 80 per cent verification. A critical study of the methods now used in the attempts at scientific long-range weather forecasting and an evaluation of their relative merits for different parts of the world is much needed.

Nature of long-range forecasting.—What is long-range weather forecasting? This question at once raises thoughts of forecasting now what the weather for next month, next summer, next fall and winter will be. The long-range forecast is beyond the realm of storms already in existence and which by their movement may be likely to affect us some time next week. Long-range forecasting, dealing with the weather abnormalities of particular months and seasons, therefore, has but little in common with day-to-day forecasting or with its extension, the forecasting on Saturday what the general character of the weather during the coming week will be. (1)

Value of and demand for long-range forecasts.—Farmers, city people, merchants, manufacturers, politicians, statesmen, engineers, all would find many uses for general scientific weather forecasts a month or more in advance. The farmer has good need for them. In the opinion of a county farm adviser, for example:

In general, accurate seasonal forecasting would tend to establish a more permanent type form of agriculture, insure more profitable crops, enable the farmer to replenish and maintain soil fertility and reduce somewhat the hazards of agriculture. (2).

For want of such forecasts, western farmers have paid a "rainmaker" thousands of dollars at a time (3). Business men (4), transportation people (5), and water-supply

or power engineers (6) especially value advance indications of seasonal weather, even when of a general character. "In many lines of goods," says Douglas, "the general character of the weather has a definite and direct influence on sales; in others the effect is present but indirect; therefore, any predictions of the general character of the weather months in advance are of decided value to the business man. Without predictions the weather factor becomes guesswork." (4) "Waste of water could be reduced," says Rowe, "thus making it possible to increase the area of agricultural land cultivated." (6) In other words, reasonably dependable long-range weather forecasts would reduce the cost of living.

Fake forecasts; almanac, astrological, and others.—*The fight against them.*—There is no use discussing in detail here those "forecasts" of the almanac kind, detailing or generalizing, on some worthless scheme, the weather usual for each month (7). "Poor Robin" (8) and Dean Swift's satire on Partridge two centuries ago (9) were the opening shots of the long campaign against quack forecasters. Nor need we feel concerned when given "warnings" of weather disasters "impending" a fortnight to a year or more in advance. Howlers of such calamities have been roundly attacked by scientists time and again. In 1875 C. M. Woodward's dramatic exposé of one planetary scheme led the way for other scientific attacks in this country (10). Weather Bureau officials and others, notably Cleveland Abbe (11), and Garriott (12), Moore alone (13), and with several other officials (14), Wren (15), Walz (16), Marvin (17), Carpenter (18), editors (19) and other writers have been unsparing of their criticism of the fake or inadequate systems in use in the United States. Here during the past 10 years well over 50 long-rangers of greater or lesser repute have been publishing and, in a great many cases, accepting money for worthless or damaging forecasts. European countries also support quack forecasters in number, against whom the attacks of scientists have been as strong as in the United States (20). Hellmann lists 96 by name and analyzes and criticizes their methods (20). He characterizes such prophets as "conceited, positive, more or less fanatic, eager for a fray." He says they use the same method against critics—picking out the best hits and keeping the poor ones silent. They are self-praising; they quote

¹ Essentially as presented at U. S. Weather Bureau Staff Meeting, Washington, D. C., May 13, 1926.

letters from people in high positions, and stigmatize meteorologists and scientific societies. Their friends and protectors belong largely to the sensational daily press, which opens its columns to them and occasionally carries some propaganda in their favor. It is difficult to say whether they are honest, says Hellmann, though some surely are (21). Probably no country in the world is free. Walker mentions the hold of astrologers and almanacs in India, for example (22).

In view of the harm done by spurious warnings Cleveland Abbe was moved to write hopefully that—

the time must soon come when a general law shall forbid the publication of weather predictions and storm warnings, especially those of a sensational character, by others than properly licensed persons (23).

Abbe did not say on what bases licenses could be issued, but it is not unlikely that he had in mind some consideration of the following points: (1) The candidate's training as a meteorologist, (2) his ability to demonstrate the probability of success of forecasts of the sort he proposed to make, and (3) his willingness to present to prospective customers a statement concerning his system of forecasting signed by a committee of, say, three competent scientists.

Predicting climatic normals.—Another type of forecast more respectable than the almanac or astrological guesses, but not real forecasts, is the prediction of climatic normals (24). Such forecasts have even been officially made. Our pilot charts, issued by the United States Hydrographic Office with the cooperation of the Weather Bureau, years ago used to carry "forecast for the month" where now they say "average conditions." The Mexican weather service formerly published "Tiempo probable durante el año meteorológico de 19— en la República Mexicana," (8vo, 8–10 pp.) (25). Recently the Signal Corps meteorologist, Capt. B. J. Sherry, was issuing, toward the end of each month, a statement of the normal weather for the succeeding month, calling it a forecast. In the low latitude of Panama the weather is so steady that prediction according to normals would have a verification of 85 per cent, the hydrographer there once told the writer.

Those who predict weather from actual or supposed occurrences on special dates, "critical days," such as the equinoxes, Candlemas, St. Swithin's, or the date of first snowfall, do no better than guesswork (26). Hellmann has traced this type of forecasting, based on January, back at least to the eighth century (27).

Biological forecasts.—We are amused rather than informed or misled by the usual autumn pronouncements of this or that old farmer or hunter who has noticed the flight of geese, examined the fur of a woodchuck, looked at a goosebone, observed the nature of a muskrat house, the abundance of nuts in squirrels' stores, and what not. (28). Josh Billings in his almanac, in 1870 wrote (29):

When yu see 13 geese walking injun file and toeing in yu can deliberately bet yure last surviving dollar on a hard winter, and grate fluktuosness during the next season in the price of cowhide boots.

Some biological forecasters will seek to tell you whether the winter is to begin early or late and about when it is to end, by observing the position and relative length of the central brown division between the black ends of fuzzy caterpillars: And don't look at more than one caterpillar! Such forecasts are about as dependable as that by a Minnesota Indian a few years ago, who expected a cold winter because he saw Neighbor White Man put in a large supply of coal. John Burroughs, however, on

observing Arctic birds in the northeastern United States early in December, 1917, gave newspapers a correct forecast of an extraordinarily cold winter to come.

Character and dependability of forecasts.—To say "there will be a cold winter" does not mean much. People want to know for their own locality about when the cold weather will set in; the extent to which mild periods will mitigate the winter; the average degree of cold (30) and the number of days and their amounts below the freezing point (31), and when spring will come. And they need some proof that the forecast is much better founded than ordinary guesswork. Forecasts must be specific and reasonably accurate if they are to be useful.

"Specific" and "reasonably accurate" are variously interpreted. Some consider a statement of trend up or down, from the preceding year sufficiently explicit (32) and 60 to 75 per cent verification a useful degree of accuracy (33). But a forecast based on a relationship no closer than this may be no forecast at all. Thus, Walker, in discussing "Some sources of error" (34), reminds us of the strong temptation to think there is a relationship if two curves run markedly parallel. The use of changes from year to year instead of the actual values results in a curious paradox. For example, he made a chance drawing of 28 trends, plotted them and then made an inverted plot and moved it one value to the right of the original. The two curves showed a 64 per cent trend relation, while that between the actual values was only 15 per cent, an amount quite useless for forecasting. Another drawing would probably have shown smaller percentages, while the average for a large number of such samplings would be 50 and 0.

On low average verifications, one must be willing to take some risk and have sufficient resources and faith to carry on through the many successive failures likely to occur. Obviously, as is shown by Walker's statement, one trouble with a verification of only 60 per cent is the chance that unrelated variations or errors in the data used may have been responsible for 10 or 20 per cent of the correspondence and that the apparent relationship on which the forecasts may be based is not real. Furthermore, it has been found that a correlation continuing for years may suddenly cease or become opposite (35).

Experience in Jamaica.—Most meteorologists, before they will forecast for general issue, must see indications that may be stated quantitatively, a probable verification, as shown by 50 or 100 years of record, of not less than 75 or 80 per cent, and an extreme unlikelihood of two bad failures in succession. An experience of the late Maxwell Hall, in Jamaica, illustrates this last point:

Forecasts for monthly rainfall were commenced in 1885 and discontinued in 1886; of these 80 per cent were correct, but the subject required more attention than I could give it, and when a large rainfall was forecast for May, 1886, which proved unusually dry, and when with an average forecast for June, 1886, heavy rains fell June 5 and 6, and floods did great damage, it was clearly time to stop this mode of forecasting (36).

If the rains had occurred only a week earlier, his forecast would have been a marked success. Later, another forecast failed, though based on an apparently close relationship between droughts and maximum sun spots published in *Nature* (49: 339):

In 1893 I gave out that that year and the next few years would probably be drier than usual—the sun-spot maximum was then approaching, and 1891 had been unusually wet—but 1893 proved to be still wetter, and it was not until two or three years after the maximum in 1893 that drought was severely felt in certain parts of the island, and the connection preserved (36).

Apparently Hall made no further long-range forecasts. His record was too short. Pickering later, with a much

longer series of years, confirmed Hall's experience that droughts followed rather than attended sun spot maxima (and minima), and successfully forecast the onset of the severe drought beginning in 1919 (37).

Experience with India's monsoon forecasts.—After early failure to achieve sufficient success in long-range forecasting in India, says Walker (38)—

A preliminary examination (in 1908) led to a formula for forecasting the monsoon rainfall of the whole of India, and a relationship² of 58 per cent with the actual rainfall was indicated; and during the 16 years 1909–1924, the formula was fully answered by expectations. So small a relationship as 0.58 does not justify a forecast unless the abnormalities are fairly marked; but this condition has been satisfied in nine years out of the 16, and in 8 years out of the 9 the rains were in excess or defect when this was given by the formula.

[Improved formulae for northwest India and Peninsular rainfall with 0.76 correlation coefficient are now used.]

As we shall need an idea of the values of relationships of this kind for purposes of forecasting, some further consideration is necessary. Taking the simplest case, in which either an excess or defect of rain is predicted, success turns on the condition that the probable error of the estimate of the amount of rain shall be less than the amount of excess (or defect) indicated by the data; and, in fact, smallness in the relationship both diminishes the amount indicated and increases the probable error of the estimate.

THE BASIS OF CALCULATION

If we decide that it is useless to issue forecasts that will not, on the average, be right 4 times out of 5, it follows mathematically that if the relationship be 80 per cent [correlation coefficient 0.8] circumstances will justify a forecast in half the occasion; if 70 per cent there is a 3 to 2 chance against the indication of any one occasion being definite enough; for 50 per cent the odds are 6 to 1 against; for 40 per cent 18 to 1; for 30 per cent 130 to 1; and for 20 per cent 25,000 to 1. So unless the relationship is of 50 per cent, occasions for a justifiable prediction will occur too rarely for practical purposes. These figures would be modified if forecasts of ["normal"] conditions were also made, but the general result would not be fundamentally different.

Later, Sir Gilbert Walker presented a more detailed statement and showed that for successes on the average 4 times out of 5 strong indications at certain times would justify a forecast on a much smaller correlation coefficient than when the indications were more or less uncertain. Thus while we should have to have a correlation coefficient of about 0.8 before we should be justified in making regular forecasts, a correlation coefficient of 0.5 would justify an occasional forecast having a probable success 4 times out of 5 if the forecasted departure were something over twice that required for forecasting with a correlation coefficient of 0.8 (39).

In conclusion, Walker says (40):

It must regretfully be admitted that the majority of the methods employed in seasonal predictions have been false; and insistence on strict conformity to the rules—in other words the principles of probability is not mere pedantry. The larger variations of seasonal rainfall, pressure, and temperature are in general not isolated phenomena, but are linked up with big variations in other parts of the earth, so that there is every cause for hopefulness regarding the possibility of understanding and predicting them; but many researches needing time and money are first necessary, and it is highly desirable in the interest of meteorology that as little as possible should be done by careless work to diminish public confidence in the possibilities of long-range forecasting.

Two or three successive failures in a seasonal forecast on the strength of which farmers and business men were governing their operations would mean financial ruin to many. This could not be remedied by many more successes in subsequent years, even supposing, as would be unlikely, the users still retained faith in the forecaster. This is different from the run of the weather. Ruinous

strings of years may occur, but the farmer has to take what comes next. A false prediction of a drought one year followed by even a correctly predicted drought the next would constitute a 50 per cent verification that would, if followed, be much worse than the result of a farmer's expecting and preparing for good rains both years.

Beginning with empirical forecasting.—The few dynamic principles of daily and weekly forecasting now known (41) are based on experience and investigations involving records of thousands of days or weeks. Corresponding principles of seasonal forecasting on physical grounds, on the contrary, can hardly be built on the 5, 10, 30, 60, or even 100 records of months or seasons of the same name, which constitute our available data, and this for only a fraction of the earth's surface. Over enormous areas we do not know what the weather is or has been. How sure could we be of a forecast for to-morrow if our first daily weather records over an area within one day's weather reach had been made only two or three months ago and not yet mapped for the whole region for any day? Though we did not know the immediate causes of the storms whose appearance and approach were reported, we should, nevertheless, be able to make useful predictions for at least portions of our area, not only from the reports from other places but also from empirically established local sequences, e. g., the normal cyclonic sequence. This appears to be the present status of long-range forecasting. Some forecasts are made for favored points, but scientific long-range weather forecasts are not yet generally available, probably not only because our records are still of insufficient length and world-wide scope to provide adequate bases for them. Meteorologists are mostly agreed that the fundamental problem of long-range forecasting is that of the physical bases of world weather, as yet not fully known, nor, indeed, knowable till the earth is far better covered with a network of stations than at present (42). Nevertheless, some, McEwen, for example (43), are using empirical rules, which, supported by a working hypothesis, can provide useful forecasts and tide us over the learning period.

Conclusion.—While the bibliography in this paper includes many references to present-day, more or less successful, scientific long-range weather forecasting, it does not pretend to cover this field even in part. A much needed investigation in scientific long-range forecasting is a critical examination of the numerous methods now or formerly employed and an attempt to determine for those found of value the probable applicability to various parts of the world.

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BERLAGE ON EAST MONSOON FORECASTING FOR JAVA¹

By ALFRED J. HENRY

The author points out that curves representing the monthly mean deviations of the meteorological elements from the normal over an extensive area, that includes Australia, the Malay Archipelago, and probably the whole of the Indian Ocean, show a fairly regular periodicity in which a three-year cycle is prominent.

Like all other periodicities thus far discovered, this one breaks down; some disturbing influence reduces the amplitude of the deviations, or even destroys them altogether. The best examples of regular epochs of maximum pressure are those of 1885, 1888, 1891, and 1896, 1899, 1902, respectively, with a break between

Six-Monthly overlapping Means of the Deviations from the normal Monthly Means
1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930

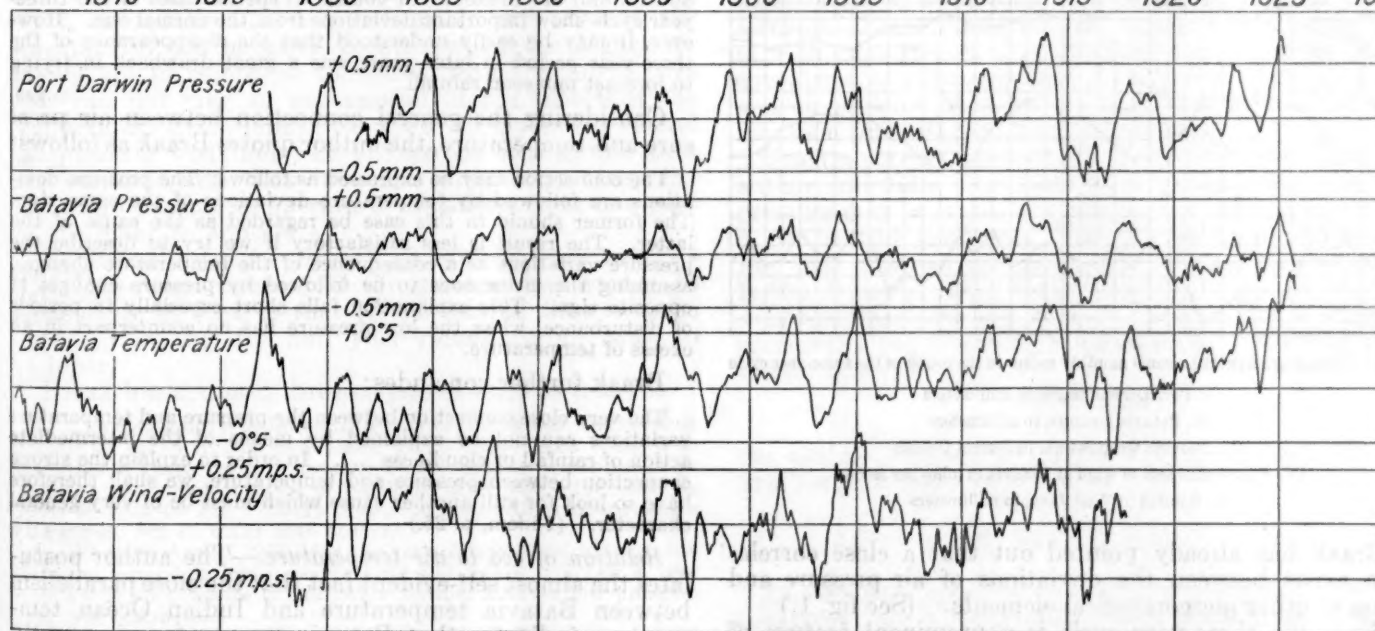


FIG. 1

Figure 1 contains a number of curves showing the march of pressure and temperature at Batavia over a period of 65 years, and for a shorter interval for other elements.

The Port Darwin pressure curve, for reasons given by Braak (1), is unique in that pressure passes from a maximum to a minimum and then to a second maximum within a period of three years.

1891 and 1896. Another series of oscillations with a distinct three-year period gave maxima in 1911 and 1914, and one might find a regular succession of maxima separated by intervals of three years from 1896 up to 1914, but from the 1914 maximum up to the present date the three-year period seems entirely lost; there is, however, one important maximum at the close of 1918, and others follow in 1923 and 1925.

¹ Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia Verhandelingen No. 20. 1927.

The author suggests that the influences which interrupt the regular waves are in some way connected with the relative sun-spot numbers. Epochs of sun-spot maxima are characterized by a damping of the air pressure curve, as may be seen from the Port Darwin trace for sun-spot maxima of 1883 and 1893. It may also be seen from this curve that no prominent maxima occur therein between 1881 and 1885 and between 1891 and 1896. The tendency is less clearly shown at sun-spot maximum of 1905 and 1917, yet shortly after 1905 air pressure remained below normal for several years, and the 1918 maximum rises out of one of the most striking depressions of the curve.

The Batavia pressure curve, the second from the top, is quite similar to Port Darwin, although the amplitude of Port Darwin deviations is almost twice as great as those of Batavia.

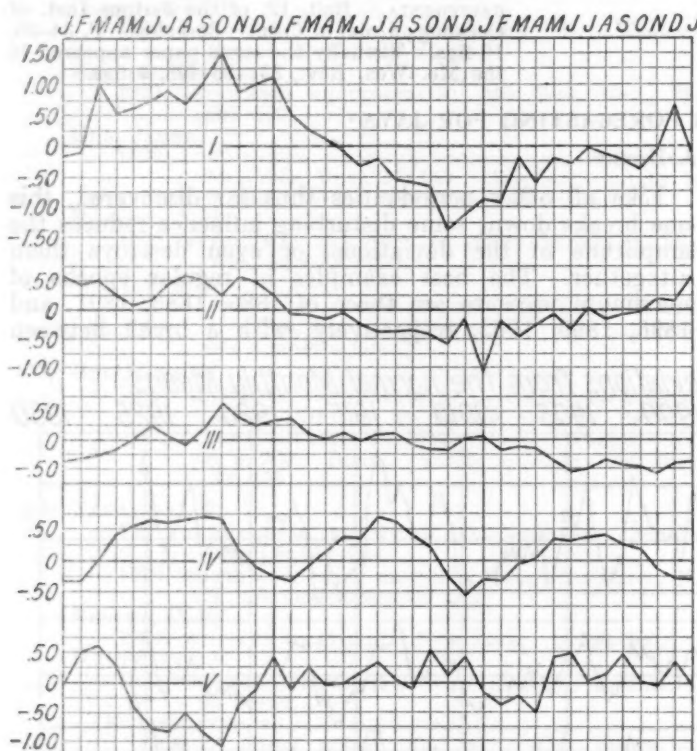


FIG. 2.—Deviations from the normal monthly means in the course of the three-year cycle

- I. Port Darwin pressure, millimeters
- II. Batavia pressure, in millimeters
- III. Batavia temperature, in degrees Celsius
- IV. East component of wind at Batavia in miles per second
- V. Rainfall in West Java, in millimeters

Braak has already pointed out that a close correlation exists between the deviations of air pressure and those of other meteorological elements. (See fig. 1.)

Since the three-year cycle is a prominent feature of the different curves Doctor Berlage asks what is the normal type of such a cycle? The series of waves showing maxima in 1885, 1888, 1891 is the one that is least disturbed. It shows rapid falls in 1886, 1889, 1892, while the barometer takes two years to rise from one minimum to the next maximum, thus suggesting that we can not adequately represent the oscillations by a simple harmonic one. How far this is the case is best shown by taking the means of the corresponding monthly deviations in each wave. These "quasi-normal" values are shown by the curves of Figure 2.

The first year of the cycle is a high-pressure year at both Port Darwin and Batavia; it may, however, open with pressure below normal at Port Darwin and above normal at Batavia. In a normal cycle a high-pressure year is followed by a year of falling barometer (transition year) and this again by one of rising barometer.

During the high-pressure year temperature rises and attains its maximum at the close of the year at the very moment of maximum pressure. Then follows two years of gradually falling temperature and a minimum is reached at the close of the third year.

While the pressure and temperature curves have not the same shape, they strongly suggest that the pressure-deviations are followed by temperature deviations of the same sign.

The east monsoon of the three successive years are characterized by decreasing wind force, the strongest east winds corresponding with the maximum of the pressure curve. The strongest west winds occur at the time of minimum pressure, i. e. in the west monsoon preceding the wet year. The high-pressure year is characterized by a very dry east monsoon, the next year by a wet east monsoon. As a normal east monsoon is also a dry season we find here the basis for the public opinion that two dry east monsoons are generally followed by a wet east monsoon. Abnormally high rainfall occurs in the west monsoon preceding the abnormally dry and persistent east monsoon. The relatively driest west monsoon is the one which corresponds with the barometric minimum and strongest west winds.

The author stresses the relations between air pressure, temperature, and rainfall. He says:

I wish to emphasize how intimately air pressure, temperature, and rainfall are related. Of course all special cases of the three-year cycle show important deviations from the normal one. However, it may be easily understood that the disappearance of the three-year period in later years was a great drawback in trying to forecast monsoon rainfall.

Considering the general connection between air pressure and temperature, the author quotes Braak as follows:

The connection may be expressed as follows: The pressure deviations are followed by temperature deviations of the same sign. The former should in this case be regarded as the cause of the latter. The result is less satisfactory if we try to describe the pressure variations as a consequence of the temperature changes, assuming the latter ones to be followed by pressure changes of opposite sign. This explanation falls short especially in periods of disturbance, when the low pressure has no counterpart in an excess of temperature.

Braak further concludes:

The very close connection between the pressure and temperature variations can not be explained by means of the intermediate action of rainfall or cloudiness ... In order to explain the strong connection between pressure and temperature, we shall therefore have to look for still another cause which must be of very general character. (1 idem, p. 25.)

Relation of sea to air temperature.—The author postulates the almost self-evident fact that the close parallelism between Batavia temperature and Indian Ocean temperature indicates that Batavia temperature is greatly dominated by sea temperature and he expresses the relation in the form of an equation as follows:

$$T(t) = aP(t - t_0) \quad (1)$$

Deviation of sea surface temperature from the normal at time t is denoted by $T(t)$, atmospheric pressure by $P(t)$, and the lag of time between corresponding deviations of both elements, assuming it to be constant, by t_0 , as in the above formula. Temperature variations in the sea surface throughout the Archipelago are, however,

not uniform. Braak discovered a second type in the eastern half, as indicated in the next following paragraph.

When this curve for the eastern part is compared with the Batavia curve it appears that the difference between them arises principally from the fact that a number of waves, which are of quite secondary importance in the Batavia curve, have developed into waves of primary importance in the Makassar-Bima curve (not reproduced). They already exist, however, in the initial state of development in the Batavia variations.

Interpretation of the three-year cycle.—According to Braak cosmical influences are inadequate to explain the three-year cycle and he shows how it is the result of a self-regulating process, the principal features of which are given below:

1. *Development of the maxima and minima of pressure deviations.*—Low air pressure increases the temperature, especially in the higher air-layers by means of the stronger ascending air movement, which causes an increase of condensation energy. The increase of temperature is in its turn the cause of a further lowering of air pressure. During high air pressure the supply of condensation energy is smaller than normal and the temperature relatively low, by which effect the development of high air pressure is supported. In both cases the effect of pressure and temperature is one of mutual reinforcement.

2. *Change, following the maxima and the minima.*—During the formation of the maximum, a temperature deviation which counteracts the pressure deviation, is developing itself in the lower layers. It is the result of different influences among which the decreased or increased supply of cold air from higher latitudes is probably playing an important part. This pressure deviation is gradually growing stronger until the change sets in.

3. *Passing through the normal state.*—When after the maximum or the minimum the decreasing or increasing air pressure has reached the normal value, it will continue to decrease or increase, because the temperature in the higher air layers is in retard with regard to that in the lower ones.

With reference to the lag above mentioned, the author asks whether this might make the value indicated by t_0 in equation (1) comprehensible and answers the question in the negative because when the higher air layers are in retard as compared with the lower ones this can not give an explanation of the fact that the temperature deviations of the lower air layers lag behind air pressure variations; he prefers the assumption that sea currents with their immense latent heat cause the lag while bearing temperature variations from one part of the globe to another.

Empirical rules for forecasting east-monsoon rains.—The long-range forecast of the greatest importance to agriculture in Java is that of the rainfall that is to be expected in the dry half year running from May to October.

Braak has deduced three empirical rules as follows:

1. The maximum is followed by a year of transition. As maxima should be taken in this case those which follow each other with intervals of three years or more. Those maxima which manifest themselves after an interval of less than three years, for example those of 1904-05 and 1913-14 should be regarded as disturbances and should not be taken into account.

2. When on April 1, following the year of transition, air pressure is below normal, a low pressure year will follow. When a year afterwards air pressure is still below normal another low pressure year will follow, etc.

3. When on April 1 (the transition years sub Figure one [under rule 1] being excluded air pressure is normal, or above the normal, a high-pressure year will follow. (1, p. 40.)

Forecasts made on this basis were successful in the majority of cases. However, the occasional unavoidable failures prompted us to the exercise of greater prudence and the minute inspection of all factors which might have any influence upon the rainfall. Concerning the failures I can not do better than quote the author when he says:

I may recall the forecast given in 1925. Looking at the Port Darwin pressure curve one will immediately recognize 1924 as a

year of transition. Now, in January, February, and March, 1925, the monthly mean pressure deviations at Port Darwin and Batavia proved to be

0.32—1.00—0.34 mm.

—1.38—0.63—0.73 mm. respectively. Application of the second rule yielded the result that a low-pressure year was to be expected and a corresponding wet east-monsoon. However, a sudden rise of the barometer during April, the monthly mean value of the deviation attaining at Batavia +0.57 mm. withheld Doctor Braak and the present writer who wished to wait for the Port Darwin value, from giving a monsoon forecast even in the course of May. Finally the Port Darwin mean monthly pressure value of April being known, viz. +0.07 mm., and at Batavia yielding a May value +0.11 mm., thus showing a decrease after the April maximum, we emitted our monsoon forecast in the first days of June, fortunately much too late for agriculture to take it into account; rainfall would probably be slightly in excess. The east-monsoon of 1925, however, proved to be the driest ever recorded.

I have dwelt upon this case to show how very intricate these questions are and in the second place how dependent we are on the practical circumstances under which the forecasts have to be emitted. If we had known the Port Darwin pressure variation of May, viz. +0.68 mm., our forecast would evidently have been better.

Another handicap under which the Javanese forecasters labored was that while as a rule pressure conditions at the beginning of a monsoon season were apt to remain constant, cases arose in which they changed suddenly in the middle of the season.

Two groups of correlation coefficients were computed, the first being between West Java rain in July and August with pressure at Port Darwin, Batavia, Manila and India (for the latter the mean of Calcutta, Madras, and Bombay was used) for the five pairs of months November-December to July-August. The second group correlated West Java rain in September and October with air pressure in the same pairs of months except that an additional pair, September-October was added and for the same stations. Since the coefficients of the second group were in each case greater than those of the first that fact is considered as indicating that the relation between rainfall and air pressure becomes the more intimate as the east-monsoon progresses in its development.

From a consideration of the above and other facts the author concludes that however important Port Darwin pressure may be in the development of the east monsoon, it can not be used as a basis for the rainfall forecast. For that purpose one must use pressure deviations in India, Batavia, and Manila and perhaps one of the soundest bases for the rainfall forecast is the Batavia pressure in the preceding west monsoon. Starting from the formula

$$\Delta R = -a\Delta B \dots\dots\dots (18)$$

the author develops successive improvements until the final form of equation is reached, as given below:

$$\Delta R = -a(\Delta B_1 - 0.5\Delta B_2) + b\Delta T - c\Delta V - k \dots\dots (22)$$

In the above equation, a , b , and c are empirical positive constants; ΔB_1 is the pressure deviation at Batavia in the west monsoon that immediately preceded the expected east monsoon and ΔB_2 is the pressure deviation at the same place in the west monsoon, that is the *second* west monsoon preceding the expected east monsoon; ΔT is the deviation from the normal of the 9 a. m. Singapore temperature in February, March, and April; ΔV is a measure of the wind direction on the southwest side of Celebes; it is obtained by finding the quotient—

rainfall on windward side Mount Lompoc Batang.
rainfall on leeward side Mount Lompoc Batang

The deviation of this quotient from the normal value gives the factor used in the equation. The constant k is seemingly based on the 6.8-year rainfall cycle of northern Peru and is to be applied only in those years when rains are due according to the cycle. It is applied in the sense that there will be an intensification of the drought in the east monsoon every 6.8 years.

SUMMARY OF RESULTS

1. It seems possible to calculate approximately in the first days of May the rainfall in Java in the second half of the east monsoon, that is in most cases July, August, September, October, by a formula in which the independent variables are only three meteorological elements drawn from stations in the neighborhood.

2. The confidence which that formula inspires is based on the fact that it yields satisfactory results in almost every case of a sequence of 47 years in which control is possible and has yielded the right result the first time it was applied, viz, in 1926.

3. Dry and wet east monsoons are so systematically distributed in a seven-year and a three-year cycle, that even without applying our rainfall formula we are able to indicate correctly at least most of the very dry and very wet ones.

Correction is required in the first place because many sun spots keep pressure lower and east monsoons wetter than normal and few sun spots keep pressure higher and east monsoons drier than normal (regular cases).

4. Some unknown influences may for some time disturb the regular scheme (pathological cases).¹

5. Sudden rises of pressure and corresponding droughts occur at sun-spot minima (singular cases).

6. Our rainfall formula masters the regular and pathological cases; it is, however, powerless with respect to singular cases, such as the east monsoons of 1913 and 1923.

LITERATURE CITED

(1) BRAAK, DR. C.

1919. ATMOSPHERIC VARIATIONS OF SHORT AND LONG DURATION IN THE MALAY ARCHIPELAGO AND THE POSSIBILITY TO FORECAST THEM. *Verhandelingen No. 5 Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia, Java.*

¹ The author uses the word "pathological" merely for identification purposes. A used it means years in which some outstanding difference from the results found in normal years appear.

RECENT CONTRIBUTIONS TO HYGROMETRY

By S. P. FERGUSON

During the past 10 years there has occurred an encouraging increase in the number of investigations and publications relating to hygrometry, a large part of which is due to the growing use of "air-conditioning" processes where the quality of a manufactured product depends upon the control of atmospheric humidity. Of the works reviewed briefly in this note, the papers by Dr. A. Norman Shaw, the "Discussion on Hygrometry" and papers in the "Dictionary of Applied Physics" already are well known to physicists, but are included in order to bring them before the staff of the Weather Bureau.

(1) A. NORMAN SHAW.

IMPROVED METHODS IN HYGROMETRY. (Trans. Roy. Soc. of Canada, Series III, Vol. X, 1916).

RELATIVE HUMIDITY. (In same Transactions, Vol. XI, 1917.)

(2) SIR NAPIER SHAW, EZER GRIFFITHS, F. J. W. WHIPPLE AND OTHERS.

A DISCUSSION ON HYGROMETRY. (Proc. Phys. Soc. London, Vol. XXXIV, 1922.)

(3) S. SKINNER.

HUMIDITY. (Article in "A Dictionary of Applied Physics" by Richard Glazebrook and others, Vol. 3, 1924, published by Macmillan, London.)

(4) GEORGE PORTER PAINE.

THE AERODYNAMICS OF THE PSYCHROMETER. (Annals, Astron. Obs. of Harvard College, Vol. 87, Part 1, 1925.)

(5) ARNOLD ROMBERG and L. W. BLAU.

A NEW HYGROMETER. (Jour. Opt. Soc. of America, Vol. 13, No. 6, December, 1926.)

(6) HERMANN BONGARDS.

FEUCHTIGKEITSMESSUNG. (Published by R. Oldenbourg, München and Berlin, 1926.)

(7) AMAD NATH PURI.

INVESTIGATIONS ON THE BEHAVIOR OF HYGROMETRIC HAIRS. (Quar. Jour. Roy. Met. Soc. Vol. 53, April, 1927.)

(1) The first paper describes experiments with several hygrometers of simple construction which apparently have an accuracy greater than that of instruments in common use. Data are given from two instruments, both of the modified chemical type, one measuring the vapor-pressure and the other the varying weight of a quantity of phosphorus pentoxide; these instruments probably are very satisfactory in the laboratory but are not suitable for continuous use by meteorological observers. Of greater interest and importance to meteorologists is the "Summary of the Limitations of Hygro-

metric Methods in General Use," based on the author's studies, abstracted as follows:

The chemical and vapor-pressure methods usually are elaborate and require expert attention and "research" conditions, which, if available and the conditions are constant, admit of determinations of humidity within 0.1 per cent of its true value; but, under ordinary conditions errors of less than 2 or 3 per cent are difficult to eliminate. These methods are almost useless for the examination of a rapidly varying humidity, giving merely the average value during the time of observation.

With dew-point methods, under the most favorable circumstances, an accuracy of greater than 1 per cent can not be assured. If the relative humidity is less than 20 per cent or if the temperature is below 5° C., errors as large as 10 per cent may easily occur.

With the psychrometer, under the best conditions, a good constancy of repetition may be obtained but an absolute accuracy of within 2 per cent can not be assured. If the wet covering and attention to its ventilation are neglected, errors of greater than 5 per cent may develop under apparently normal conditions. If either the relative humidity or the temperature is low, or if the relative humidity is approaching 100 per cent the errors may be larger than 10 per cent. The former conditions for such errors are very common during the winter in cold climates. Inside steam-heated buildings, for example, the relative humidity will, when the temperature is below -30° C. outside, be sometimes as low as 5 per cent and yet be indicated as high as 20 per cent on an instrument which, without alteration, will record satisfactorily under average summer conditions.

Hygrometers of expansion, especially those employing hair, gut, or horn need very frequent recalibrations and in a few months may become almost useless. After subjection to extreme conditions there are often large "after effects" which vary in a complicated manner. If however these instruments are compared frequently with others over a large range of humidities they are the most convenient, because their sensitiveness is great, the time needed for a determination of humidity is short and the procedure merely that of reading a scale or chart. They have, perhaps, been over-maligned by many observers, but it must be admitted that the necessity for frequent recalibration renders them unsuitable for accurate work outside the laboratory.

The second paper discusses from the viewpoint of physics and physiology the confusion due to giving relative humidity and absolute humidity equal prominence and suggests that "treatment of the subject can be kept quite clear if the term 'relative humidity' is kept in its proper place as a derived quantity of secondary importance."

(2) This excellent work, probably the most thorough presentation of modern technique by English authorities, comprises 8 memoirs and 18 short notes in the form of a discussion. An introductory chapter, "The Measurement of Atmospheric Humidity," by Sir Napier Shaw,

discusses the subject from the viewpoint of the daily meteorological observer who must be regarded "as a tool user, not as a tool minder, still less as a toolmaker. For that reason, meteorological practice in the measurement of humidity is limited to the wet and dry bulb thermometers, which are used almost everywhere, and the hair hygrometer, which is used for the term hour observations in Norway and for self-recording hygrometers everywhere." The author's remarks on the two methods are condensed as follows:

There is little difficulty about the use of the wet and dry bulb so long as the temperature of both remains above the freezing point. The formula for reduction depends to some extent upon wind velocity, and in dry climates, like that of Egypt, a small error in formula may lead to ridiculous results in practice; if anything vital turned on the results, there is little doubt that a system would be evolved without difficulty. But as soon as the freezing point is passed the wet bulb ceases to be an effective instrument. The water has no definite freezing point, but freezes at all sorts of temperatures, and when the water is frozen the capillary action, upon which the moistening depends, ceases altogether. The directions for the treatment of the wet bulb during frost are palliatives designed to carry on in an occasional emergency. Nobody in London could possibly satisfy himself from the evidence at his disposal whether a reading of humidity during frost entered in a schedule from, say, Yarmouth, or on board a ship, represented frozen bulb, supercooled wet bulb, semidry bulb or dry bulb. In these circumstances, equality of reading of wet bulb and dry bulb, the most probable occurrences in the circumstances, has no effective meaning. * * * Moreover, below the freezing point the amount of water vapor in the atmosphere and its variations becomes very small. There is very little to go upon when dealing with absolute measures. It is, however, remarkable that the shrinkage and slackening of cordage and other results upon animal and vegetable fibres are apparently as effective as at any other temperature.

The conclusion at which I have arrived is that the wet bulb is useless for temperatures just below freezing and should be discarded. Descriptions of the endeavor to find a suitable formula abound in meteorological literature; but practically, the subject has not advanced at all in my time.

So far as I know, the hair hygrometer is the only instrument which is available in those circumstances to give a reading which can be interpreted. Since the publication of Regnault's classical memoir, physicists have been very shy of it, because it offends the first principles of a physical laboratory; it does not always repeat the same reading in the same physical conditions. It suffers from age and misuse and other infirmities. But in view of the general failure of more orthodox methods, the prejudice of the physical laboratory against the instrument is a little overdone and unreasonable. I suppose that there is a limit beyond which even the most accurate physical experiment does not repeat itself. * * * And in an atmosphere where rejoicing in the triumphant accuracy of one part in hundred thousand is a common experience, it is annoying to be brought up by a matter that can not keep steady within 5 per cent. Yet hair is apparently a more definite physical quantity than wet muslin.

Certain it is that the story which the recording hair hygrometer tells of the variation of the humidity of the atmosphere at any temperature is an extremely romantic and interesting one; and even when its tabulated figures are erroneous, its sequences are valuable evidence of the course of events.

I have little experience of its working. I do not much like covering it with a damp cloth or wetting the hairs and calling the reading 95 per cent; and yet, considering that the atmosphere is always in turbulent motion, and a process of mixing is always going on, it is really doubtful whether the actual humidity of a small portion of the atmosphere is a physical quantity to be measured by any instrument freely exposed to the passing air.

In the longest paper of this series Dr. Ezer Griffiths, of the National Physical Laboratory, describes original experiments made with the object of developing suitable apparatus for the measurement of humidity at low temperatures. "The three classical methods—the wet and dry bulb hygrometer, the dew-point apparatus, and the hair hygrometer—were studied and so modified that they could be used in a low temperature room inaccessible to the observer. An important feature of the work was the elimination of artificial disturbance of conditions in and near the measuring instruments caused by the presence of the observer, etc. New instruments described (of

special interest to meteorologists) are a continuously recording resistance-thermometer type of psychrometer having an automatic cam device for rapidly dipping and withdrawing the bulb at periodic intervals from a reservoir of water, a distant reading type of dew-point apparatus in which the change of reflecting power of a cooled surface (due to condensation) was measured by a minute thermopile, and a distant reading hair hygrometer in which the clock drum of the ordinary recorder was replaced by a tubular rheostat. The pointer (of the recorder) was pressed into contact with the rheostat when a reading was desired; the two portions of the resistance winding then constituted the two arms of a Wheatstone's bridge. A number of other forms of hygrometers were also studied and a convenient form of apparatus for the calibration of hygrometers over a wide range of humidities is described." From lengthy experience with various methods the author concludes that the dew point is the most convenient of all methods for low-temperature work; consequently, it was employed as a standard of reference for most of the work recorded in his memoir.

In "The Theory of the Hair Hygrometer," Dr. F. J. W. Whipple, now superintendent of Kew Observatory, discusses papers by de Saussure, Regnault, Srenovsky, and others; a summary of this memoir follows:

Microscopic examination of a hair shows that it contains numerous cells; some are filled with coloring matter whilst others contain more or less water. According to Srenovsky, when the hair is in a saturated atmosphere these pores are filled to overflowing. On the other hand, in a comparatively dry atmosphere the water in each cell will be bounded by a curved meniscus. The tendency to reduce the radius of curvature of the meniscus strains the cell walls. (When the hair is saturated there is no such strain.) It may be expected that, if the cells are elastic and are deformed in accordance with Hooke's law, the contraction of the hair as it dries will be a simple function of the relative humidity.

After discussing mathematically the effects of varying vapor pressures upon the cells of a hair the author concludes that

* * * the theory leads to the simple result that the contraction of the hair from its length when saturated is proportional to the logarithm of the relative humidity of the atmosphere. The theory should only hold good provided that the drying is not carried so far that many of the cells lose all their water. It is also certain that Hooke's law will not hold in extreme cases.

An important application of the theory is that hair hygrometers should not be used in dry atmospheres, where the contents of the hair cells may completely evaporate. It is well known that in such circumstances the readings are apt to be unreliable. No attempt should be made to carry the calibration of a hygrometer down to very low humidities; the range from 100 per cent to 20 per cent should suffice for almost all purposes.

"The Wet and Dry Bulb Hygrometer," by Principal S. Skinner, is an experimental inquiry based on Clerk Maxwell's formula for still air modified for air in motion.

The "Note on Psychrometry in a Wind Channel," by R. A. Watson Watt, describes experiments showing that the formula used in reduction of data from the ventilated psychrometer applies at air speeds of 25 to 40 meters a second without appreciable change of constants from those appropriate to a speed of 4.5 meters a second.

The other memoirs and the discussion contain much that is of interest to meteorologists, but are largely devoted to industrial uses of hygrometers.

(3) This is a brief summary of present-day technique including descriptions of standard measuring instruments and humidifying systems. (It may be added that the same volume contains authoritative chapters on meteorology and allied subjects extremely useful to the student and investigator.)

(4) This work, conducted under the auspices of the National Research Council, describes "an investigation

of the magnitude of the combined effects of external work, viscosity, heat conduction, and turbulence on the state of moist air flowing past an obstacle with a view to an experimental determination of an accurate psychrometric formula"; this investigation, taking its departure from the hydrodynamic equations and the Maxwell diffusion equations, has fallen into five parts, the main results of which are outlined in five papers:

I. Theory and Experiments Relating to Energy Transformations in a Jet of Air.

II. Experiments Relating to Energy Transformations in the Region of Eddies Set up by an Obstacle in a Jet of Air.

III. Theory and Experiments Relating to Energy Transformations in the Region of Eddies set up by a Wet Obstacle in a Jet of Moist Air.

IV. An Aerodynamic Formula for the Psychrometer and its Experimental Verification.

V. Verification of the Aerodynamic Theory of the Psychrometer in the Case of a Small-Scale Apparatus.

The methods and apparatus were carefully planned and elaborate, the essentials being a small wind tunnel and accessories in which the thermometer bulbs were exposed. A special chemical hygrometer and a modified Assmann psychrometer were used as reference standards and the experimental data used in developing the new psychrometric formula were obtained chiefly from wet and dry bulb thermocouples, which were accurate within about 0.006°C . The practical validity of the formula was tested by means of the modified Assmann instrument, an important improvement in which consisted of a partition placed in the central tube to prevent turbulent mixture of air currents from the separate thermometers. The tests indicate that, at ordinary room temperatures and through a range of relative humidity from 12 to 76 per cent, the computed and observed values of humidity agreed within about 1 per cent. One result of interest is that, increasing the velocity of ventilating current to 15 meters a second causes spraying of water from the wet bulb.

(5) The hygrometer described is simple and continuous indicating; a value of the humidity is obtained by balancing a column of atmospheric air against one of air saturated with water vapor and observing the effect, on a suspended vane, of the difference of pressure due to different densities. It is more sensitive than the Regnault-Alluard type of dew-point instrument and can be made a hundred times as sensitive if required. The feature perhaps most important to meteorologists is that the instrument may be used as a standard of reference at temperatures below 0°C .; the table of data indicates satisfactory determinations at -15° , hence, that we now have a means of standardizing hair hygrometers at temperatures where the psychrometer is useless.

(6) This is probably the most complete and thorough of recent textbooks on hygrometry. Its 322 pages contain just the information most useful to all who are interested in the many applications of hygrometry in science and industry. The first 40 pages contain a discussion of the physics of gases and water vapor, including the kinetic theory of gases, the laws of Boyle, Mariotte, Dalton, and Gay-Lussac, the phases (forms) of water, weight and density, heat capacity, and the basic methods of measuring pressures and temperatures, with appropriate mathematical formulae and illustrations of simple measuring instruments.

The remainder of the volume is a description of methods of measurement, with many illustrations of apparatus suitable for different purposes or needs, hygrometrical tables, and a bibliography.

The chemical or "absolute" method is well illustrated by gravimetric and volumetric instruments of Brunner, Baumhoser, Schwackhofer, Petterson, Rudorff, and Edelmann, the saturation process by instruments of Rudorff and Wolfert, and the low-temperature apparatus of Sonder. The condensation method (dew-point) is represented by 13 instruments, beginning with Daniell and ending with Bongards, of which perhaps the best known are those of Regnault, Alluard, and Crova.

The evaporation method (psychrometric) is introduced by descriptions of atmometers of Wild and Piche, followed by a discussion of the theory of the psychrometer, including the behavior of the instrument in moving and still air, with various coverings and with frozen covering. Typical instruments are described, of which the more important are the well-known Assmann psychrometer, meteorological psychographs by Pastorelli & Rapkin, industrial instruments by Parks-Cramer, and electrical and distance-recording instruments by Hartmann and Braun, Brown, and Siemens and Halske.

Following the section on the psychrometer, nearly all of the last third of the volume is devoted to methods of measurement by means of hygrometric substances, of which 71 pages are assigned to the hair hygrometer. Methods of preparation of materials, the evaluation of scales, the behavior and durability of hair, and apparatus for testing instruments are described in considerable detail and well illustrated. Eight direct-reading instruments by de Saussure, Koppe, Lambrecht, and others; four hygographs by Richard, Fuess, Lambrecht, and Edney; and a distance-recording instrument by Lambrecht are well described and illustrated. The use and possibilities of optical and electrical devices are discussed briefly.

A translation of this excellent work and a new text of the kind in English are greatly to be desired.

(7) Quoting the author's summary, this paper describes a study of four types of hair hygrometers in which the total load on the hairs consists of a weight. These were taken through a series of humidity changes controlled by sulphuric acid-water mixtures. It is shown that, when the hair is loaded with a weight of two grams, or more, it undergoes a slow extension which extends over a period of several weeks. Hair under a smaller load shows no such effect and the readings at various humidities can be reproduced with sufficient accuracy to measure humidity within 2 per cent.

Alterations in length of hair due to changes in humidity show a hysteresis effect which is apparently in the reverse direction to that when measurements are taken in terms of change of weight.

A simple form of weight hair hygrometer has been described which can be used for measuring the vapor pressure of moist substances. (This consists of a small quantity of hair, cut into small pieces and cleaned by washing with benzine, placed in a weighing bottle.)

Two facts of interest are indicated by this review:

(1) Although through improvement of methods it is now possible to determine the humidity of a measured quantity of air with fair precision, there is no process capable of indicating the humidity of the free air with an accuracy of within ± 2 per cent, even under favorable conditions. (It may be that, as in the case of anemometers, free-air conditions will not permit greater accuracy.) (2) An increasing tolerance for the hair hygrometer on the part of physicists. It is being realized that unsuspected errors of the psychrometer and other forms of hygrometers, due to conditions of observation, etc., may be larger than those hitherto attributed to the hair hygrometer.

DAS KLIMA ALS WETTERGESAMTHEIT (CLIMATE AS TOTALITY OF THE WEATHER)

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[Magn. Metl. Observatory, Slutsk (formerly Pavlovsk) near Leningrad]

(Translated from the German and summarized by Esak S. Nichols, Weather Bureau Office, San Jose, Calif., November, 1926)

The author shows that the usual method of presenting climatic data by means, averages, extremes, and sums of the various meteorological elements separately is untrue to nature; for these elements occur and act in combination only. For instance, the physiological processes of a plant at a given moment are not controlled by temperature, humidity, and precipitation separately, but by the combined action of these and the other meteorological elements; that is, by the weather. Therefore neither the single elements, nor still less their means, have any meaning for the plant. Further, it is quite clear that the same set of means of the principal climatic elements does not guarantee the same weather and, therefore, does not have the same meaning for the plant.

Quotations from several authors are given to show increasing dissatisfaction with present climatological methods. The opinion is expressed that it would be of great benefit to specialists along many lines, notably agronomists, botanists, physicians, and engineers, to receive climatic statements, not in the form of means, extremes, and frequencies of the separate meteorological elements (or at least not only thus) but in the form of a group of weather types, with statement of their frequencies. Changes of types should be reported also; but types that occur so seldom that they may be termed "accidental" may, for most purposes, be omitted from reports.

Climate is conceived as a complex of actual natural phenomena—the weather sequence—and is likened to a living organism. The climate of a place is defined as "the totality of the weather observed there." Since the weather of each moment or of each day is extremely complicated and, in our higher latitude is, in addition, exceedingly variable, the expressing of climate in accordance with this definition is a problem whose solution requires a method entirely different from, and greatly more complicated than, that now used. Evidently the observational material must be classified according to weather types determined in gradations of values of the various meteorological elements. Such a system of classification is developed.

The primary unit chosen is the "weather case" or "weather hap," which is the weather that occurs at a place on any date (of 24 hours, night and day). The climate then consists of a succession of weather cases, which are to be classified into weather types. Of course, the greater the number of elements considered and the smaller their gradations the greater will be the number of types obtained. The following scheme is suggested:

- I. Mean daily temperature; intervals, 5° C. (9° F.).
- II. Change of mean temperature from that of preceding day; same intervals.
- III. Daily range of temperature; same intervals.
- IV. Mean daily relative humidity; intervals, 20 per cent.
- V. Variations of cloudiness, night and day, separately.
- VI. Precipitation, before or after noon separately.
- VII. Wind direction, night and day, separately, to 16 points.
- VIII. Force of the wind; calm, light, moderate, etc.
- IX. Thunderstorm, with or without downpour of rain; distant thunderstorm.
- X. Snow cover; depth and condition.
- XI. Frost; dew; wet or dry ground in summer.

XII. Rime; ice storm; snow showers and rainfall in winter.

Then each day's weather is placed in a weather type determined by the limits (in accordance with the above scale) between which each of that day's elements falls. Record of the classification is made in cipher code on a card, one for each day, which is then filed with similar cards for other dates, forming a weather card index.

The code employed is very ingenious. By combining four letters, like a four-lettered word, the proper type can be designated, considering all the elements listed above. By using each of the 26 letters of the alphabet in both upper and lower cases and in both boldface and ordinary type, 104 characters are obtained, which present over 110,000,000 possible combinations using four characters at a time—far more than the number necessary to indicate all weather types possible anywhere in the world. It is very easy to arrange the cards for any period in groups according to similarity of types, and thus the frequencies of the latter can be counted. For various purposes the classification may be simplified by reducing the number of elements considered; or, on the other hand, other elements than those listed may be added or may be substituted for some of those on the list.

The general method proposed is illustrated by an accompanying diagram in five sections (not reproduced), which shows the frequencies of various weather types, using a greatly shortened list of elements, determined from records for 20 years at Pavlovsk during July, August, and September (a section of the diagram for each month separately), and from a 10-year record at Batavia, Java, during February and August (each month in a separate section). First, the relative frequencies of the type groups determined by daily mean temperature and daily mean relative humidity are proportional to the areas of squares, which are, in each section of the diagram, arranged according to increase of temperature upward and of humidity from left to right. Each square is divided into differently colored areas which are proportional to the frequencies of specified conditions of cloudiness within the respective temperature-humidity groups represented by the squares. Shading, by means of sets of parallel lines differently inclined further divides the temperature-humidity-cloudiness areas according to frequencies of various degrees of wind force. And the figures, 1, 2, 3, etc., are used to indicate frequencies of temperature range within specified limits. Each figure is entered upon any shaded colored area the number of times in 10 years the indicated daily temperature range occurs within the temperature-humidity-cloudiness-wind type specified by the particular area.

Then from this diagram we can easily obtain both the relative and absolute frequencies of the several types determined according to the five meteorological elements used, or according to any of the five desired; e. g., since we find in the July diagram for Pavlovsk the figure 2 entered twenty and one-half times in the light-blue unshaded area in the square for mean temperature 12½°–17½° C. and relative humidity 60–80 per cent, we understand (in accordance with explanatory notes) that 20½ July days in 10 years have mean temperature between 12½° and 17½° C., a temperature range of 5° to 10° C., mean relative humidity from 61 to 80 per cent, moderate winds, and

considerable cloudiness during the whole day. Certain signs are placed before or after the proper figures on the diagram to indicate the occurrence of precipitation, thunderstorm, and frost before or after noon, respectively, on certain type days. Thus an excellent idea of the weather that prevails (the climate) at Pavlovsk and Batavia during the months considered can be easily and quickly obtained. Seasonal changes and differences between climates can thus be strikingly shown by this method.

Reference is made to the publication in Russian in "Met. Wjestnik, 1925, No. 7," of an article by the author containing an exposition of the principles of the method, including details of the cipher code used in classification. Also, in a letter to Dr. Charles F. Brooks, the author refers to an address given in 1921 before the Congress of the Russian Society of Amateurs of Universal Knowledge, explaining the method in its primitive form; and to complete exposition before his observatory fellow members in 1924 and before the Russian Meteorological Committee of Geographical Society and Russian Geophysics Congress in April and May, 1925.

DISCUSSION

In his letter to Doctor Brooks, Mr. Federov refers to the group of papers in the MONTHLY WEATHER REVIEW for October, 1925, entitled "Papers on the Relation of the Atmosphere to Human Comfort," by C. F. Brooks and others; and states that the chief features underlying "my work are common with yours, and especially with E. S. Nichols." The outstanding common features of Federov's method and that considered in my paper, which is entitled "A Classification of Weather Types," are the recognition of the need of studying the combinations of the various meteorological elements (the weather), the classification of these combinations into a series of

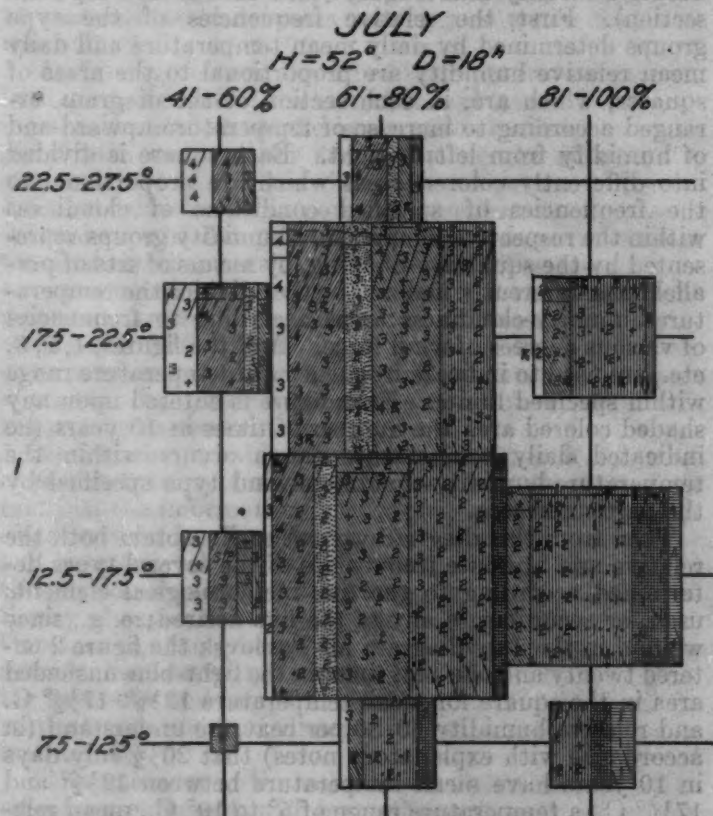


FIG. 1

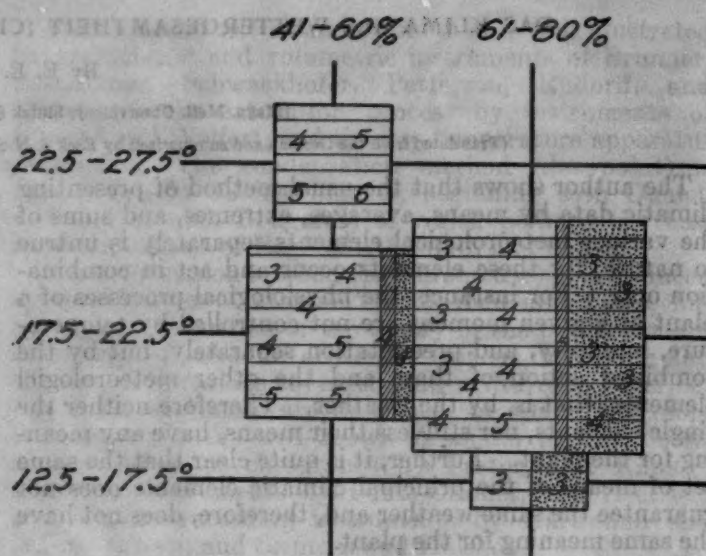


FIG. 2

Mean daily temperature: Indicated by figures at the left of the squares, in °C.
Mean daily relative humidity, per cent: Indicated by figures above the squares.
Cloudiness:

- The whole day bright.
- Cloudy at night; daytime clear.
- The whole day faintly cloudy.
- Clear at night, daytime cloudy.
- Considerable cloudiness the whole day.
- Heavy clouds the whole day.
- Continuous rain the whole day.
- Wind force: Light or calm.
- Quiet at night, windy by day.
- Moderate wind.
- Strong wind.

Amplitude of temperature (daily range): Indicated by figures entered on the shaded areas:

- Below 5° C., by the figure 1.
- Between 5° and 10°, by the figure 2.
- Between 10° and 15°, by the figure 3, etc.
- Rain: Thunderstorm; (T). Frost: (F). These symbols placed before or after the figures, according as the occurrence was before or after noon.

weather types determined by gradations of values of the elements, determining the frequencies of the various types, and (for some purposes) the designation of types by a letter code. The main differences between the methods arise from choices of different units of weather to be classified.

Fedorov's use of the day's weather as a unit is a valuable method of analyzing weather records, and his diagram is an ingenious method of showing graphically much regarding the climate of a place. However, the daily unit is so complicated that the actual state of the atmosphere at any time is not shown in this way; for instance, the first steps in classification are according to daily means of temperature and relative humidity; and, while temperature range is given by the fifth step, no attempt is made to indicate variations in relative humid-

ity throughout the day, and therefore no idea regarding the actual temperature-humidity combinations can be obtained without making assumptions and computations.

Fedorov states in a footnote: "Perhaps it would be more natural to take the weather of a moment, but practically it is not satisfactory." However, this must be done; that it is practicable is shown in my previous paper and in the following article entitled "Frequencies of Weather Types at San Jose, Calif." Our unit is relatively simple, consisting of the instantaneous values of such elements as we may wish to consider. By analyzing observations taken at a regular time at a station we learn the frequencies of various types at that time of day for the month or other period desired. Conditions at other times of day are found by analyzing such other observations as may be desired and available.

Whether Federov's method or mine, or some other, shall be used in any particular study depends in part on the purpose in view; for instance, it appears that students of effects of weather upon human comfort and efficiency would prefer conditions in the morning, at noon, in the evening, etc., considered separately, by my method; while some botanical problems might be solved better by Federov's.

I have prepared diagrams according to Federov's scheme for San Jose, Calif., using data for the two months, January and July, 1926, separately. As might be expected, the number of types is intermediate between the numbers for Pavlovsk and Batavia. It is worthy of note, however, that an additional grade for daily range of temperature, above the highest used for Pavlovsk, was necessary; also that no thunder was recorded during either month considered, and that rain and frost occurred in the winter month only.

It is regretted that, on account of the impracticability of printing the necessary colors, none of the diagrams according to Federov's method is reproduced herewith.—*E. S. Nichols.*

Since the above summary and remarks were written Federov's paper has been published,¹ accompanied by diagrams in which shading is employed instead of colors for indicating cloudiness. While the diagrams are in this way not nearly so clear and striking as the originals, they are made suitable for reproduction in black and white. Figure 1, is a copy of the revised diagram for July at Pavlovsk, and Figure 2 has been prepared from San Jose data for July, 1926, according to the new method. It is suggested that if the reader will color Figures 1 and 2 in accordance with the original plan, he will obtain an adequate conception of Federov's scheme.—*E. S. Nichols.*

¹ "Das Wetter," 44 Jahrgang, Heft 6/7.

FREQUENCIES OF WEATHER TYPES AT SAN JOSE, CALIF.

By ESEK S. NICHOLS

[Weather Bureau, San Jose, Calif., November, 1926]

In accordance with my scale for classification of weather types (1), frequencies of various weather types at San Jose, Calif., have been determined from thrice-daily observations during the months of January, April, July, and October, for the five-year period, July, 1921, to April, 1926. Table 1, herewith, gives resulting data in tabular form; but conditions may be shown more clearly by a graphical method, which can be merely illustrated here, our space being limited. Classification begins with temperature and humidity, the importance of which is, therefore, emphasized.¹

TABLE 1.—Percentage frequencies of various weather types at San Jose, Calif., at thrice-daily observations during January, April, July, and October

	H ₁			H ₂			H ₃			H ₄			H ₅		
	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂
January: 6:10 and 6:40 a. m. observations:															
T ₁ —S ₁ —				1			1			1			1	1	
T ₁ —S ₂ —							1	1		1			1		
T ₁ —S ₃ —							1	1		1			1		
T ₁ —S ₄ —							1	1		1			1		
T ₁ —S ₅ —							1	1		1			1		
T ₁ —S ₆ —							1	1		1			1		
T ₁ —S ₇ —							1	1		1			1		
T ₁ —S ₈ —							1	1		1			1		
T ₁ —S ₉ —							1	1		1			1		
T ₁ —S ₁₀ —							1	1		1			1		
T ₁ —S ₁₁ —							1	1		1			1		
T ₁ —S ₁₂ —							1	1		1			1		
T ₁ —S ₁₃ —							1	1		1			1		
T ₁ —S ₁₄ —							1	1		1			1		
T ₁ —S ₁₅ —							1	1		1			1		
T ₁ —S ₁₆ —							1	1		1			1		
T ₁ —S ₁₇ —							1	1		1			1		
T ₁ —S ₁₈ —							1	1		1			1		
T ₁ —S ₁₉ —							1	1		1			1		
T ₁ —S ₂₀ —							1	1		1			1		
T ₁ —S ₂₁ —							1	1		1			1		
T ₁ —S ₂₂ —							1	1		1			1		
T ₁ —S ₂₃ —							1	1		1			1		
T ₁ —S ₂₄ —							1	1		1			1		
T ₁ —S ₂₅ —							1	1		1			1		
T ₁ —S ₂₆ —							1	1		1			1		
T ₁ —S ₂₇ —							1	1		1			1		
T ₁ —S ₂₈ —							1	1		1			1		
T ₁ —S ₂₉ —							1	1		1			1		
T ₁ —S ₃₀ —							1	1		1			1		
T ₁ —S ₃₁ —							1	1		1			1		
T ₁ —S ₃₂ —							1	1		1			1		
T ₁ —S ₃₃ —							1	1		1			1		
T ₁ —S ₃₄ —							1	1		1			1		
T ₁ —S ₃₅ —							1	1		1			1		
T ₁ —S ₃₆ —							1	1		1			1		
T ₁ —S ₃₇ —							1	1		1			1		
T ₁ —S ₃₈ —							1	1		1			1		
T ₁ —S ₃₉ —							1	1		1			1		
T ₁ —S ₄₀ —							1	1		1			1		
T ₁ —S ₄₁ —							1	1		1			1		
T ₁ —S ₄₂ —							1	1		1			1		
T ₁ —S ₄₃ —							1	1		1			1		
T ₁ —S ₄₄ —							1	1		1			1		
T ₁ —S ₄₅ —							1	1		1			1		
T ₁ —S ₄₆ —							1	1		1			1		
T ₁ —S ₄₇ —							1	1		1			1		
T ₁ —S ₄₈ —							1	1		1			1		
T ₁ —S ₄₉ —							1	1		1			1		
T ₁ —S ₅₀ —							1	1		1			1		
T ₁ —S ₅₁ —							1	1		1			1		
T ₁ —S ₅₂ —							1	1		1			1		
T ₁ —S ₅₃ —							1	1		1			1		
T ₁ —S ₅₄ —							1	1		1			1		
T ₁ —S ₅₅ —							1	1		1			1		
T ₁ —S ₅₆ —							1	1		1			1		
T ₁ —S ₅₇ —							1	1		1			1		
T ₁ —S ₅₈ —							1	1		1			1		
T ₁ —S ₅₉ —							1	1		1			1		
T ₁ —S ₆₀ —							1	1		1			1		
T ₁ —S ₆₁ —							1	1		1			1		
T ₁ —S ₆₂ —							1	1		1			1		
T ₁ —S ₆₃ —							1	1		1			1		
T ₁ —S ₆₄ —							1	1		1			1		
T ₁ —S ₆₅ —							1	1		1			1		
T ₁ —S ₆₆ —							1	1		1			1		
T ₁ —S ₆₇ —							1	1		1			1		
T ₁ —S ₆₈ —							1	1		1			1		
T ₁ —S ₆₉ —							1	1		1			1		
T ₁ —S ₇₀ —							1	1		1			1		
T ₁ —S ₇₁ —							1	1		1			1		
T ₁ —S ₇₂ —							1	1		1			1		
T ₁ —S ₇₃ —							1	1		1			1		
T ₁ —S ₇₄ —							1	1		1			1		
T ₁ —S ₇₅ —							1	1		1			1		
T ₁ —S ₇₆ —							1	1		1			1		
T ₁ —S ₇₇ —							1	1		1			1		
T ₁ —S ₇₈ —							1	1		1			1		
T ₁ —S ₇₉ —							1	1		1			1		
T ₁ —S ₈₀ —							1	1		1			1		
T ₁ —S ₈₁ —							1	1		1			1		
T ₁ —S ₈₂ —							1	1		1			1		
T ₁ —S ₈₃ —							1	1		1			1		
T ₁ —S ₈₄ —							1	1		1			1		
T ₁ —S ₈₅ —							1	1		1			1		
T ₁ —S ₈₆ —							1	1		1			1		
T ₁ —S ₈₇ —							1	1		1			1		
T ₁ —S ₈₈ —							1	1		1			1		
T ₁ —S ₈₉ —							1	1		1			1		
T ₁ —S ₉₀ —							1	1		1			1		
T ₁ —S ₉₁ —							1	1		1			1		
T ₁ —S ₉₂ —							1	1		1			1		
T ₁ —S ₉₃ —							1	1		1			1		
T ₁ —S ₉₄ —							1	1		1			1		
T ₁ —S ₉₅ —							1	1		1			1		
T ₁ —S ₉₆ —							1	1		1			1		
T ₁ —S ₉₇ —							1	1		1			1		
T ₁ —S ₉₈ —							1	1		1			1		
T ₁ —S ₉₉ —							1	1		1			1		
T ₁ —S ₁₀₀ —							1	1		1			1		

¹ Temperature, relative humidity, wind velocity, and cloudiness are the meteorological elements used. Intervals are indicated on Figure No. 1 and in legends thereto; therefore the scale is not repeated here.

TABLE 1.—Percentage frequencies of various weather types at San Jose, Calif., at thrice-daily observations during January, April, July, and October—Continued

	H ₁			H ₂			H ₃			H ₄			H ₅		
	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂	W ₀	W ₁	W ₂
January (---): 4:40 p. m. observations:															
T ₁ —	S ₁ —	1	—	3	—	—	1	—	—	—	—	—	—	—	—
	S ₂ —	—	—	1	—	—	1	—	—	1	—	—	—	—	—
	S ₃ —	—	—	1	1	—	1	—	—	—	—	—	—	—	—
T ₂ —	S ₁ —	1	—	13	1	—	21	5	—	3	2	—	—	—	—
	S ₂ —	—	—	1	—	—	4	2	—	3	—	—	—	—	—
	S ₃ —	—	1	1	1	—	7	2	—	9	1	1	—	1	—
T ₃ —	S ₁ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₂ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
April (++): 6:10 and 6:40 a. m. observations:															
T ₁ —	S ₁ —	—	—	—	—	—	—	—	—	1	—	—	—	1	—
	S ₂ —	—	—	—	—	—	—	1	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	5	1	—	8	—	—	—	10	—
T ₂ —	S ₁ —	—	—	1	—	—	1	—	—	1	—	—	—	7	—
	S ₂ —	—	—	—	—	—	—	—	—	15	1	—	—	29	—
	S ₃ —	—	—	—	—	—	—	—	—	4	—	—	—	1	—
T ₃ —	S ₁ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₂ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
April (++): Noon observations:															
T ₁ —	S ₁ —	—	1	—	1	—	—	—	—	—	—	—	—	—	—
	S ₂ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T ₂ —	S ₁ —	1	3	—	4	—	—	—	—	—	—	—	—	—	—
	S ₂ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T ₃ —	S ₁ —	—	1	—	1	—	—	—	—	—	—	—	—	—	—
	S ₂ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T ₄ —	S ₁ —	1	2	—	11	8	—	11	4	—	—	—	—	—	—
	S ₂ —	—	—	3	2	—	—	3	4	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	7	4	1	—	—	—	—	—
T ₅ —	S ₁ —	—	—	1	—	—	—	—	—	—	—	—	—	—	—
	S ₂ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T ₆ —	S ₁ —	—	—	4	1	1	—	2	—	—	—	—	—	—	—
	S ₂ —	—	—	1	—	—	—	1	—	—	—	—	—	—	—
	S ₃ —	—	—	1	1	—	6	1	—	3	—	—	1	1	1
April (++): 4:40 p. m. observations:															
T ₁ —	S ₁ —	—	—	1	1	—	—	—	—	—	—	—	—	—	—
	S ₂ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S ₃ —	—	—	—	—	—	—	—	—	—	—	—	—	—	—

within the temperature-humidity groups. The temperature-humidity-wind types are further divided according to cloudiness, as indicated by shaded areas proportional to frequencies. Cloudy is indicated by black areas, clear by clear areas, and partly cloudy by crosshatching. Thus, since we find in the noon group of figures for July (reproduced as Figure 1) in the H_0 column, and the T_0 row, a clear area covering 13 small squares under W_1 , we see that 13 per cent of the cases at noon in July have temperature between 60° and 74° F., relative humidity between 50 and 74 per cent, clear sky, and wind velocity from 10 to 19 miles per hour.

If for any purpose it is desired to leave out of consideration any of the four meteorological elements used, the proper areas and percentages may be combined; this may be carried to the extent of eliminating all but any single desired element. In Figure 1 it is particularly easy to eliminate all but temperature and humidity by considering simply the percentage numbers on the face of the chart. Also, Table 1 is very convenient in combining and rearranging. We may readily rearrange our data so as to emphasize other elements than temperature and humidity. For instance, Dorno considers temperature and wind velocity more important in relation to human comfort (2); so in Figure 2 relative areas have been drawn for July noon data, using columns for wind velocity instead of for humidity, tabular percentage-frequency data having been properly rearranged accordingly. Of course, the details of the system may be modified, also, by changing the intervals used for any element, by substituting other elements for those employed, by the addition of other elements (such as intensity of radiation, atmospheric pressure, precipitation, etc.), and in other ways.

Thus, in his paper already mentioned, Dorno refers to the importance of considering departures of atmospheric temperature from that of the human body (36.5° C., 98.6° F.). Our temperature group T_{+3} , 96° to 105° F.,

includes temperatures at and near that referred to. Other type groups may be thought of as being below or above the body temperature instead of being referred to zero of the usual scale.

If two days have the same sequence of weather types they may be said to have essentially the same weather. An examination of the regular thrice-daily observations taken at San Jose during July, 1926—apparently a month with fairly uniform weather—gave 28 different sequences for the 31 days. This illustrates the great complexity of the weather; any day is likely to differ from its neighbors, even when major features only are considered.

The principal purpose of this study is to show a method of indicating the atmospheric conditions that occur at a place. Having information in the form exemplified, it is possible for a person to tell with considerable accuracy how suitable a given climate would be for a given purpose, basing his conclusions upon his experiences with the various weather types elsewhere.

Furthermore, it should be possible to express numerically, and hence to appraise, the relative suitability of the different types for certain purposes. Thus, we might compute the rate of cooling of man under each type in accordance with the formula developed by Brooks and Donnelly (3) and (4).

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THE ST. LOUIS TORNADO OF SEPTEMBER 29, 1927

By MONTROSE W. HAYES, Meteorologist, U. S. Weather Bureau, St. Louis, Mo.

On September 29, 1927, at 1 p. m., a tornado moved across St. Louis, passed over the Mississippi River, and dissipated in Illinois, about $3\frac{1}{2}$ miles from the river.

The weather map for 7 a. m., September 29, showed a barometric depression of considerable intensity over Nebraska and Kansas. Special observations at 1 p. m., the time of the occurrence of the storm, made in the Missouri and upper Mississippi Valleys, placed the center of the depression in western Iowa, exactly to the northwest of St. Louis, and 350 miles distant.

In St. Louis the day broke cloudy and rainy. Intermittent rain that began before daylight ended at 7:10 a. m. After the ending of the rain strato-cumulus clouds predominated, but during the forenoon the ceiling was broken and some alto-stratus clouds were visible. The sun shone for 25 minutes between 8 and 9 a. m. Shortly after 11 a. m. clouds became lower and thicker and rain began at 11:26 a. m. The rain was quite light for slightly more than an hour and a half. Low clouds were moving very rapidly from the southwest. At 12:41 p. m. lightning was seen and thunder was heard in the west. The thunderstorm rapidly overspread the west and southwest, and appeared to move to the northeast, its path being to the west of the Weather Bureau office. At 12:57 p. m. the clouds were very low, thick, and black. One large detached portion was particularly noticeable;

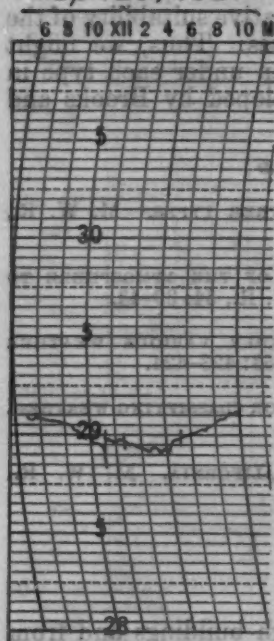
it seemed very little above the high buildings and from the Weather Bureau office it was west of and slightly to the south of the Bell Telephone Building. Although this detached cloud was quite black and angry looking no boiling motion was apparent. The rain became heavy, in a sudden downpour, at 1:02 p. m., and the wind had increased to a very high velocity by 1 p. m. The low clouds, and the rain driven by the high wind, made a solid impenetrable grayish-brown mass outside the office windows (looking to the south and west), and vision from the windows was totally obscured from 1:02 p. m. to about 1:05 p. m., when the atmosphere grew lighter. The wind force decreased materially at 1:05 p. m., but the rain continued heavy until 1:13 p. m. A special observation was begun at 1 p. m., but on account of the dark deluge of water through the instrument shelter the instruments could not be read; they were eventually read at 1:06 p. m.

The wind was strong from the southwest after 6 a. m.; at 12:35 p. m. it backed to the south, but occasionally veered to the southwest, and was not quite so strong. At 12:56 p. m. it came steadily from the south and increased in force. At 1:02 p. m. it veered to the west and blew from that direction until 1:06 p. m., at which time it became west-northwest. The maximum velocity was at the rate of 70 miles an hour in the five minutes

beginning at 12:58 p. m., and the direction was mostly south. The extreme velocity was at the rate of 96 miles an hour from the west, beginning at 1:02 p. m.

The barograph trace fell steadily until 10 a. m., when the rate of fall increased, and at about 12:50 p. m. the fall became much more pronounced. At 1:02 p. m. there was an instantaneous fall from 28.91 to 28.80, and the fall was followed immediately by an instantaneous rise to a reading of 29.02. The trace then fell steadily till 4 p. m., after which it remained almost stationary, with slight fluctuations, until 6:15 p. m., when a rise set in and prevailed through the night. A barometer reading made at 1:10 p. m. gave the following results: Actual reading corrected for temperature of the mercury, instrumental error and gravity, 28.833 inches; reduced to the station elevation (568.2 feet, or 148.6 feet lower than the barometer), 28.988 inches; reduced to sea level, 29.59 inches. Another reading, made at 2:20 p. m.,

Sept. 29, 1927



Barograph trace, St. Louis, Mo.,
September 29, 1927

gave corresponding results as follows: 28.805, 28.960, and 29.56 inches.

At the Weather Bureau office the storm was severe, but there was no general damage in the immediate vicinity. Some plate-glass windows were blown out, but the storm was not, at the time it occurred, considered more severe than heavy thunderstorms that occur from time to time. The Weather Bureau office is about $1\frac{3}{4}$ miles from the nearest edge of the tornado, as indicated by minor damage, and is about 3 miles from the center of the path of the tornado, as indicated by the greatest destruction.

The storm apparently originated in the extreme southwest portion of St. Louis and moved in a northeast direction to the neighborhood of Tower Grove and Vandeventer Avenues, a distance of 4 miles. Thus far the path was about 300 feet wide and the damage was in spots. There is considerable doubt about the progress of the tornado beyond Tower Grove and Vandeventer Avenues. It either bent northwestward or dissipated and another storm formed on Manchester Avenue, just to the west of Kingshighway, slightly more than one-half mile northwest of the path of the original storm. From Manchester and Kingshighway, across the extreme southeast corner of Forest Park, then northeastward to West Park and Taylor, a distance of three-fourths mile in a northeasterly direction, there was sporadic wreckage over a path about 300 feet wide. Then the path widened, the storm became violent, and the damage became general.

The fact that the original storm appears to have moved in a path parallel, near its terminus, to what may be called a second path, which had its origin near Manchester Avenue and Kingshighway, coupled with the observations of Dr. Clifford H. Farr, professor of botany, Washington University, would seem to indicate that it was a second and more violent formation that caused the great damage and loss of life. The notes of Doctor Farr's observations follow:

At 1 o'clock on September 29 I was waiting in the corridor on the second floor of Barnes Hospital, looking out of the north windows at the clouds. The impression which I gained by the increasing darkness was of an impending storm of some severity. I therefore stepped into a vacant room, No. 2422, in order to see the storm to the south. The window of the room was raised about 18 inches. It commanded a view south across Kingshighway (where it runs east and west) and into Forest Park in a direction parallel to the Taylor car line. The north and south stretch of Kingshighway and the car line were, however, not in view because of a wing of the hospital.

Upon entering the room I heard a sound as of an approaching train. Gusts of wind blew through the room. I went to the window to close it. As I did so the sound grew still louder, becoming a terrible roar. A dense dark cloud was resting in Forest Park. I could see across the street and some trees on the other side, but I felt that I could not see more than a block distant.

Then suddenly the scene changed. Out of this dark cloud there was organized a funnel. Judging its distance to be a block, I estimated its base resting on the ground as about 200 feet in diameter, its height about twice that of the hospital—that is, that of an eight-story building, and its diameter at the top as about 400 feet. After looking over the ground since the storm I have concluded that I visualized the funnel as nearer to me than it really was. Such a mistake would be easily made in an atmosphere of that foggy type. Now I think that the funnel when I first saw it was about three blocks away. In other words, I probably saw it just as it was toppling over the Bates statue. In this case the funnel must have been about 600 feet in diameter at the base and twice as wide at the top and perhaps 800 feet high.

Autos were running to and fro on the boulevard between me and the cloud. The trees along the street were being blown, but did not bend greatly. I marveled at so little disturbance of the trees. The funnel moved toward me; I thought directly toward me. As it approached I could see streaks in the cloud. Its outline was very sharp and clean-cut. Presently I saw boards and other objects coming out of the top of the funnel or near its upper margin. These must have come from the tennis courts which it crossed after leaving the statue. I felt that it was coming straight toward the hospital. The screen on the window was pulled loose by the suction. This distracted my attention from the funnel for a moment; and when I looked again the funnel was gone. I knew not whither. It must have then crossed Kingshighway to the Shriners' Hospital, which was not in sight from my window.

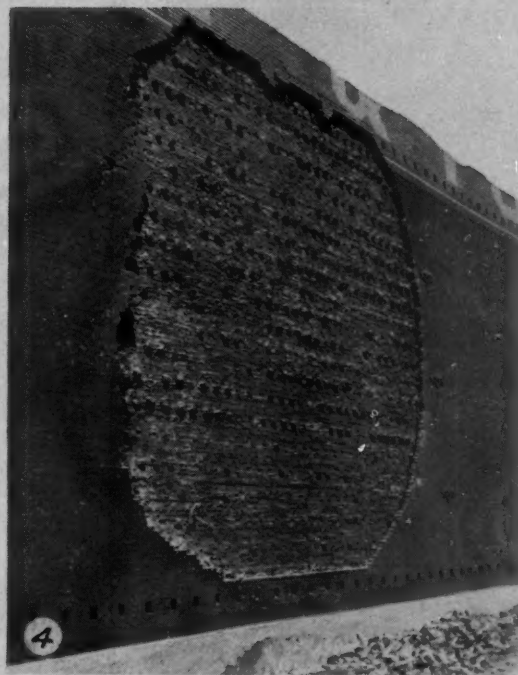
In place of the funnel, however, I saw the trees bending toward the east, before the most terrific wind that I have ever witnessed. The trees were almost horizontal; some of them were laid flat permanently. No cars were now being driven in the street. I expected to see the parked cars move, but I could not detect them doing so.

Almost immediately I heard windows in the hospital crash. One of these was a north window through which I had been looking in the corridor before I entered the room. It crashed in. Then the blow was over.

Evidently the funnel had passed to the east of us and the strong west wind which bent the trees and then broke the glass was blowing directly toward it.

I have not made a careful study of the trees in the devastated area. However, casual observations while crossing it on Delmar, Lindell, and Pine make me think that the storm may have continued throughout its course much as I saw it. It appears that in an area about one and one-fourth blocks wide that the trees are not uprooted but are twisted off above ground and the tops and debris carried away. To the west of this area there is a zone of progressively less destruction for a distance of five or six blocks in which the trees are blown to the east, as if by a west wind, and the trees, branches, and debris are left in the street. To the east of the area the margin of progressively less destruction seems to be considerably narrower.

The path was almost due southwest to northeast from West Park and Taylor to the southeast limits of Granite City, Ill., where surface conditions of the whirling motion disappeared. There was general destruction over a path $2\frac{1}{2}$ miles long and in places three-eighths mile wide, but scattered damage occurred in a zone somewhat more than $1\frac{1}{4}$ miles across at its widest place, which was from Olive and Spring northwest to Easton and Newstead. At Grand and St. Louis Avenues the path narrowed considerably and the destructive action became much less general. Then on to the northeasterly end of the path,





in Illinois, the wreckage was not widespread. In fact, it seems that over this portion of the path the tornado's tube was not continuously in contact with the ground, but the winds, which were not markedly of a whirling nature, were excessively high. An interesting phase of the storm was the finding of papers in Hillsboro, Litchfield, and Mount Olive, Ill., that belonged to people in the devastated area of St. Louis. These towns are 40 to 50 miles northeast of a point just north of the McKinley Bridge across the Mississippi, where the storm crossed the river. The papers seemed to have dropped from the sky.

The time taken in the passage of the storm from southwestern St. Louis to the southeast of Granite City, in Illinois, is not known. All reports of first damage in St. Louis place the time "about 1 p. m." An instantaneous drop and rise in the barometer trace in the Weather Bureau office (1 3/4 miles southeast of the nearest edge of the storm, and 3 miles from the center) took place at 1.02 p. m., and the extreme wind velocity (96 miles an hour) was at the same time. Reports from the Illinois side of the river place the time of the storm "a few minutes after 1 p. m."

Where the storm crossed streets lined with trees it was quite easy to trace the center of the path by the direction in which the trees were lying. Some of the trees were twisted as much as 90° before being leveled. One plainly marked feature of the storm, and an interesting one, is the fact that the damage on the left, or west side of the storm's center, as indicated by the reversed direction in which trees were laid down, was confined to a very narrow strip, while on the right, or east side there was a broad swath of damage and destruction. In fact, there were many places in which the damage did not extend more than one or two hundred feet to the west of the first tree lying in a generally easterly direction.

A comparative analysis of the storm would be impossible, but judging from the reports of the character of destruction and from the pressure falls recorded by the nearest barographs, this tornado was not as violent in a meteorological sense as the St. Louis tornado of May 27, 1896, and the southern Illinois tornado of March 18, 1925. The instantaneous fall in pressure at St. Louis University, three-fourths of a mile southeast of the center of the path of the storm, was 0.20 inch. The fall was followed by an immediate rise to the former reading. At the Weather Bureau office, also southeast of the path, but 3 miles from the storm's center, the instantaneous fall was only 0.11 inch; however, the rise, which immediately followed, was 0.22 inch. In the Little Rock, Ark., tornado of October 2, 1894, the pressure fall was 0.37 inch and the following rise was to the original reading. The barograph in St. Louis on May 27, 1896, acted very much as it did on September 29, 1927; that is, it indicated a pressure fall of 0.22 inch, and the following rise was greater, being 0.40 inch. (The barograph was about three-fourths of a mile from the center of the storm.) On March 18, 1925, a tornado occurred in southern Illinois; it was one of the severest tornadoes of record.

A barograph trace said to have been made less than a mile from the outer edge of the storm showed an instantaneous fall, and a following rise, of 0.20 inch.

Destruction of life and property is obviously no criterion of the relative severity of storms. The path of the recent storm was through a section of the city consisting mainly, but not altogether, of rather old residences, flat buildings, and stores. The construction of these buildings can not be said to have been generally poor, although it was decidedly poor in some instances. However, the construction, as a rule, was by no means what it should have been, and the fact that at least two modern apartment buildings were damaged no more than was to be expected seems to bear out this assertion. There is considerable discussion and criticism of the mortar used in the damaged and razed buildings. Other phases of construction are also being discussed and criticized to some extent, and the entire matter may result in changes in building practices. The apartment buildings mentioned had windows blown out and some parapet walls blown off. In most of the damaged buildings near the storm's center the explosive effect was plainly marked.

In St. Louis 72 people were killed; of this number several died of injuries some days or weeks after the storm. The injured numbered around 500. Fortunately there were few fires following the storm. In Illinois seven people were killed and one man died of heart failure; there were about 50 injured.

The monetary damage is, of course, not definitely known, and probably never will be. A careful survey in St. Louis indicates that, exclusive of motor cars and the contents of buildings of whatever nature, the damage amounted to \$22,000,000. In Illinois the total damage probably was less than \$3,000,000.

NOTE.—The following legends, as well as the photographs here reproduced, were made and furnished by H. J. Woods, engineer of the Missouri Inspection Bureau:

FIG. 1.—Typical destruction of residence 4017 Enright Avenue

FIG. 2.—Columbia School (public), 2742 North Garrison Avenue. Walls blown out, particularly at southwest and southeast corners; roof practically destroyed. In some instances the brickwork between the windows only the face brick remained

FIG. 3.—Bucks Stove & Range Co., east side Second Street, between Destrehan and Mallinckrodt Streets. Heavy damage occurred on upper floors of the four and five story buildings. Buildings suffered in breakage of windows and one from falling stacks

FIG. 4.—Polar Wave Ice & Fuel Co., 4428 Duncan Avenue. Ice-storage house, having 4-inch dead air space in walls, vented at top and bottom of wall, as shown in photograph. Four-inch brick outer wall forced out by air pressure during storm. Greater destruction to other parts of plant; several men killed

FIG. 5.—Three residences completely destroyed—4106, 4112, and 4114 Enright Avenue

FIG. 6.—Examples of recent construction of small apartments using hollow tile with brick facing. Doubtless conditions could have been greatly improved by proper bonding of these walls and by the use of cement mortar

FIG. 7.—Showing destruction of facing over flues due to sudden drop in barometric pressure during tornado

FIG. 8.—Looking north from alley between Olive Street and Washington Boulevard. View of the rear of residences in the 4100 block on Washington Boulevard

FIG. 9.—View of the north side of 4100 block of Washington Boulevard. NOTE.—One structure shows second floor completely wiped out and third floor of massed construction occupying former position of second floor, front room

FIGS. 10, 11.—Leonardo Fireproof Apartments, 4100 Lindell Boulevard. Part of west side shown in above photograph; entire window, including casing, on first floor, pushed out; damage to windows above. Rear view shows damage to parapet and to windows

FIG. 12.—Four O Six Six Fireproof Apartments, 4006 Lindell Boulevard. This apartment nearing completion; windows not all installed

METEOROLOGICAL CONDITIONS OVER THE SEA IN THE EASTERN MEDITERRANEAN

By H. MEREDITH, B. Sc.

The observations referred to in the following article were made on October 14, 15, and 16, 1926, during a voyage in the Mediterranean Sea between Alexandria and Malta, and consist of measurements of the sea-surface temperature, the air temperature, and relative humidity at 21 feet above the water level, together with

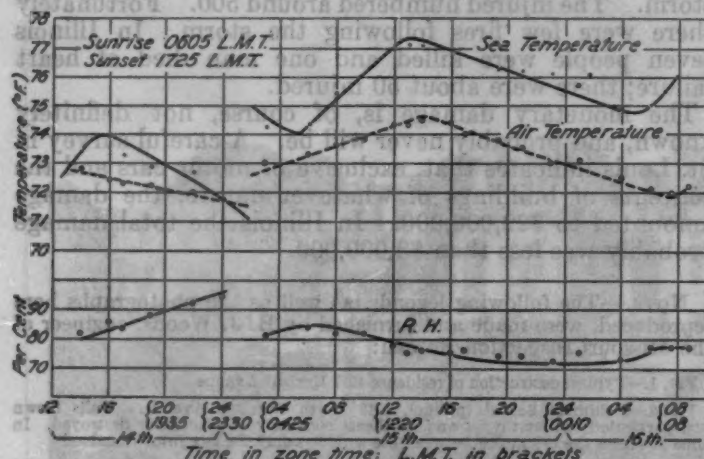
the air-temperature gradient between the heights of 13 feet and 71 feet above the sea level. The observations were taken approximately at two-hour intervals throughout the voyage. Alexandria was left at about 1400 on October 13 and Malta was reached at 1000 October 16, the ship steaming a steady 12 knots throughout. The

weather conditions remained sensibly the same during the period covered by the observations, the condition of the sea being slight to calm, with no swell.

The sea temperatures were taken by the bucket method, using a canvas bucket of the nature and dimensions described by Doctor Brooks,¹ the sample being taken from as near the surface of the sea as possible, the cast being made from well forward on the bow of the ship.

The actual temperature of the water sample was taken by means of a thermometer, previously calibrated against the air-temperature thermometer, a quick stir and rapid reading being the standard practice for each sample, while samples were continuously taken until two consecutive readings were the same. It was found that only on rare occasions were more than two samples required, indicating that drawing up water by this method from a moving vessel insures complete mixing within the sample, and errors through cooling would ensue were the thermometer allowed to remain for three minutes as recommended in the Meteorological Handbook for Observers.

In this connection tests were made of samples from three positions, namely, that of the standard position mentioned above, another from the weather side of the



bow, and a third from the lee side of the bow, the latter two positions being 15 yards aft of the former one. On only one occasion was there any difference in the readings, this exception being a very slight increase in the case of a single sample taken from the lee side (the sunny side, incidentally) about midday.

Further, provided the thermometer was kept well centered in the water in the bucket, there was no decrease in temperature during the period required (approximately 30 seconds) to take three readings. When the thermometer was allowed to touch the inside of the canvas there was naturally a sharp drop of from 0.5° to 1° F. in the reading.

On completion of the readings the bucket sample was allowed to remain filled with water. During the period intervening between observations the water would gradually ooze away and the upper portion of the bucket become dry and warm. Thus, heat lost by cooling of the wet portion of the canvas was partially counterbalanced by the heating by the sun of the dry portion. It was found that if the sample was emptied from the bucket each time, as recommended by Professor Merx,² the wooden bottom of the bucket became dry and hot and the next reading would be inaccurate through this cause. To guard still further against errors due to the bucket

being heated, it was allowed to remain in the water before bringing up a sample for such time as it took to take the readings of the air temperature and temperature gradient. Previous to pulling inboard a sample of water one or two bucketfuls would be hauled clear of the water and, by means of a sharp twist of the rope, emptied of its contents, and the bucket plunged into the water once more for the best sample.

It will thus be seen that the final sample would be expected to bear a very close approximation to the conditions actually obtaining in the upper 6 inches of the sea.

The results of the observations are plotted in the accompanying graph. Zone time is plotted along the base and, bracketed with some of the hour periods, is the corresponding local mean time. The change for "G. M. T. plus 2 hours" to "G. M. T. plus 1 hour" was made in two half-hours at midnight October 14-15.

It will be seen from the graph that a definite break occurs at midnight October 14-15, corresponding to the ship's position off Cyrenaica and is accounted for by the fact that, with certain winds from the north, a north-easterly current of 16 to 20 nautical miles per day is set up, which brings down colder water from the Dardanelles. This stream, on meeting the African coast, is turned eastward along the North African coast, where its cooling effect is soon lost.³

During the voyage the wind blew consistently from a northerly direction, and undoubtedly the cooler Dardanelles current is here portrayed, its effect being lost shortly after midnight. As a confirmatory circumstance, light fog was encountered at midnight 20 miles off Cape Ras el Tin (Cyrenaica), while the moon was seen to sink behind a dense bank of fog to landward.

On the 15th there is a rise in temperature during the day of approximately 3° F. and a fall during the night of the 15th-16th of nearly 2.5° F. Such a diurnal variation is not usually encountered in more open waters such as the Atlantic Ocean. The upward and downward slopes of the graph show a very pronounced regularity, and there are indications that the rise in temperature in the forenoon takes place at a far greater rate than the decrease afterwards, the former averaging 0.3° F. and the latter less than 0.2° F. per hour.

The maximum temperature is reached on the first day between 1340 and 1540 local mean time, and on the second day between 1220 and 1420 local mean time, giving 1400 hours as a possible maximum period.

The minimum values for both the 14th-15th and the 15th-16th are indefinite, but indicate with same assurance that the effect of sunrise on the temperature of the water is immediate and appreciable.

Whereas the maximum temperature of the uppermost layer of the soil has been found, by extrapolation of maxima at varying depths, to occur at midday, it is here found that over the sea the maximum of the upper sea surface, as measured by the bucket-sample method, occurs at least one hour later. This lag is undoubtedly due to the turbulence in the upper layers of the sea, which rapidly conveys downward the heat accumulated at the water surface. This lag, then, is a function of the sea disturbance and will tend to increase up to a certain limit, with increase in the sea disturbance, although the latter itself would have a limit beyond which it would tend to decrease this lag in the maximum temperature.

As regards the air temperatures and the relative humidities. An Assmann thermometer was used for taking the temperatures, the wet-bulb thermometer being first

¹ Mo. Wea. Rev., June 1926, 54: 241-253.

² Die Oberflächentemperature der Gewässer.

³ Monthly Meteorological Chart of the Mediterranean Basin, October.

calibrated against the dry-bulb thermometer. Readings were taken from well forward in the "eyes" of the ship, the Assmann being held on the weather side and readings taken every half minute until two consecutive readings were identical.

The points as plotted in the accompanying graph indicate temperatures less than that of the sea surface and having a diurnal range of similar magnitude to that of the sea temperature, namely 3° F. The premaximum rate of increase appears to be less than that of the sea temperatures, while the slope of the line indicating its rate of decrease in temperature after the maximum is almost parallel to that of the sea temperature for a corresponding period.

As indicated by the values for the 15th-16th, the maximum air temperature is reached about one hour after the corresponding point for the sea temperature, while a similar interval occurs between the hours of minimum temperature. This is to be expected by reason of the temperature superiority displayed throughout by the sea surface and corresponds to what occurs over the land. But since the temperature superiority of sea water over the air above it is less than for corresponding day times in the case of land, the lag of the air temperature would be expected to be of a lower order.

The fog off Ras el Tin on the night of the 14th-15th is clearly manifested by the record of the relative humidities. Apart from this phenomenon, the record indicated a distinct diurnal variation in the relative humidity of the air, with a maximum at sunrise on the 15th and a minimum in the afternoon of the same day.

As regards the temperature gradient between 13 feet and 71 feet above sea level. The apparatus used was identical with that described by N. K. Johnson in his article in the Quarterly Journal.

In brief the apparatus consisted of a pair of platinum resistance thermometer elements, placed one over the bow of the ship, 13 feet above the water, and the other at the masthead at a height of 71 feet. Both elements were protected from incoming solar radiation and were aspirated at a constant rate by means of two fans and lengths of tubing. By adapting a Wheatstone bridge circuit, the difference between the resistance of the two elements could be ascertained, and hence the difference in temperature at the two heights. Although originally designed to measure only to the nearest 0.1° C., it was found that the instrument was surprisingly accurate to 0.01° C.

Although not clearly portrayed, there are indications in the results obtained during the voyage of the following:

(a) A decrease in the lapse rate as midnight, 14th-15th, is approached. This might be expected from the fact that at midnight fog conditions abounded and the temperature of the sea and that of the air at 20 feet were equal.

(b) There are indications of a decrease in the lapse rate at sunrise on the 15th, a steady lapse rate thence to midday, when the lapse rate gradually increased until sunset.

* Quarterly Journal Meteorological Society, vol. 53, No. 221.

Meteorological data for October 14, 15, and 16

Time	1400	1600	1700	1900	2200	Midnight	0300	0600	0800	1000	1200	1300	1400	1600	1700	1920	2100	2300	0100	0400	0600	0730	0845
Sea temperature	73.4	73.9	73.3	72.9	72.7	71.8	74.3	74.4	75.5	75.5	77.1	77.1	77.1	76.9	76.3	76.3	76.2	76.1	75.8	75.0	75.1	75.5	75.4
Air temperature	72.8	72.4	72.3	72.3	72.0	71.7	73.0	73.3	73.6	73.8	74.3	74.3	74.5	74.4	74.0	73.8	73.5	73.0	73.1	72.5	72.1	72.0	72.2
Temperature gradient	-.20		-.23	-.22	-.21		-.24	-.21	-.22	-.21			-.24		-.20				-.23	-.21			
Wind (m/sec.)	3		3	4	4	5	6	7					4	3		3		0-1		3	2		4
Relative humidity	82	80	84	88	92	94	81	84	82	82	78	75	76	75	70	74	74	72	75	73	77	77	77

Sea and air temperatures are in degrees Fahrenheit. Temperature gradient is measured in degrees centigrade, negative values indicating a lapse rate between 13 and 71 feet above water level. Times are in zone times. (See text.)

ICE FORECASTING BY MEANS OF THE WEATHER

[Reprinted from U. S. Coast Guard Bulletin No. 15, "International ice observations and ice patrol service in the North Atlantic"]

One of the most important scientific problems that has confronted the ice patrol for some time is the desire to obtain advance information regarding the annual amount of ice to be expected south of Newfoundland. If the master of the *Titanic* had known, as we can clearly see to-day, that the year 1912 was one in which icebergs by the hundreds invaded the North Atlantic to low latitudes, he would probably have navigated his command farther south, and more cautiously, past the Arctic ice barrier. The amount of ice drifting out of the north into the open Atlantic is subject to great annual variations; for instance, in 1912 there were approximately 1,200 bergs counted south of Newfoundland while in 1924 there were only a total of 11. Several investigations have been made of the relation between the amounts of ice in the northeastern North Atlantic and logical contributory factors, but only a few similar papers have dealt with the ice stream past Newfoundland.

All of the investigators, Schott, Mecking, Brenneck, Weisse, and Meinardus found that the wind was the most important factor which governs the southward drift of polar ice. The ice patrol, with the assistance of the British Meteorological Office and more recently the United States Weather Bureau, has begun an investigation into the effect of the weather upon the distribution

of icebergs. It is desired, therefore, under this section devoted to weather to give a brief account of the results so far of this research work. The period embraces 47 years, 1880-1926, a series of sufficient length to permit mathematical correlation, and in this respect it has an advantage over previous works.

The results differ somewhat from those previously obtained by Mecking in that the chief importance is assigned to the variations of the pressure difference between Belle Isle, in Newfoundland, and Ivigtut, in southern Greenland, during the period December to March. The pressure difference directly affects the amount of field ice, and it has been found that there is a very close relation between the amount of field ice and the number of bergs south of Newfoundland. The field ice tends to act as a fender along the shoreward side of the Labrador current, and thus more or less prevents the bergs from stranding as they are borne southward. The truth of this statement was curiously revealed during the 1924 patrol, when the unusual absence of field ice left the season's crop of bergs to strand in northern waters. When the sea ice recedes northward, due to melting in May, the coast line becomes more and more exposed. Stranding takes place on a great scale, and the consequent supply of bergs to the Grand Banks is cut off. The iceberg

menace to steamships in the North Atlantic would be greatly diminished, or practically disappear, if sea ice did not hamper the North American coast line from February to March every year. The pressure difference between Bergen and Stykkisholm during the period October to January was also found to be of importance.

The use of pressure difference between various points furnishes the best data for forecasting purposes, because there is no room for the personal bias which may come in when charts are classified according to types. A classification of the charts of pressure anomaly over the North Atlantic during the period December to March has, however, been made, and this distinctly reveals two types of pressure distribution—a plus type, in which an excess of pressure centered in the region of Iceland, more or less dominates the Atlantic north of the Azores (see fig. 8a, p. 46), and a minus type when reverse conditions



FIG. 1.—Pressure departure map-plus type. Made by averaging the December to March pressure departures for 1881, 1891, 1895, 1900, 1902, and 1917. These years were characterized by a smaller amount of Arctic ice drifting into the western Atlantic than usual.

prevail (see fig. 8b, p. 47). (Reproduced as Figs. 1 and 2 respectively.) The plus type is subject to further classification into (1) and (2), depending upon a relatively great or moderate intensity of the excess pressure mass, both of which are reflected in a relatively very light, or light ice year, respectively, in the western North Atlantic. The minus type, although unmistakably showing a greater amount of ice than normal, does not permit subgrouping. In other words, the plus type of pressure conditions (fig. 1) exhibit a higher correlation with poor ice years than do the minus type (fig. 2) with correspondingly rich ice years. This indicates the presence of other factors such as variations in the air and water temperatures in the far north, or variations in precipitation, or perhaps an unnatural phenomenon such as an ice jam in the Arctic Archipelago.

Although the investigation is not yet completed at the present writing the results already indicate a high degree of success for such a method of ice forecasting. Correlation coefficients have been calculated between the following variables:

OUTLINE OF THE ARTICLE ON "THE CLIMATIC REGIONS OF EASTERN NORTH AMERICA"

By W. VAN ROYAN

[Clark University, Worcester, Mass., 1927]

Aim of the study: Why the eastern part of America has been treated. Data used: Koeppen's Leading Principles. Criteria used in his classification: The A climates and C, D, and E climates. Comparisons with the vegetation map: The limit of the dry zone. The isotherm to

- (a) Number of bergs (on a scale of 0 to 10).
- (b) Amount of field ice (on a scale of 0 to 10).
- (c) Pressure difference (in millibars) between Belle Isle and Ivigtut, combined with a deviation of pressure from normal at Stykkisholm during the period December to March. The mean pressure difference is calculated from the combination: $2 \times \text{Dec.} + 2 \times \text{Jan.} + 1 \times \text{Feb.} + 1 \times \text{March}$ and this mean is combined with the pressure deviation at Stykkisholm in the proportion of 6 to 1.
- (d) The pressure difference between Stykkisholm and Bergen during the period October to January, inclusive, December being given double weight.

The correlation coefficients employed in the preparation of the forecast were as follows:

Between (a) and (b)	+0.85
Between (a) and (c)	-0.58
Between (a) and (d)	-0.63



FIG. 2.—Pressure departure map-minus type. Made by averaging the pressure departures for the months December to March in the years 1885, 1890, 1903, 1912, and 1921. These years were characterized by a greater amount of Arctic ice drifting into the western Atlantic than usual.

At the end of March a forecast of the number of bergs can be prepared by means of the regression equation:

$$\text{Bergs} = 4.8 - 0.08 (c) - 0.12 (d)$$

At the end of the field ice season, April 15, the number of bergs, May to July, can be predicted very closely by making use of the high correlation between field ice and bergs.

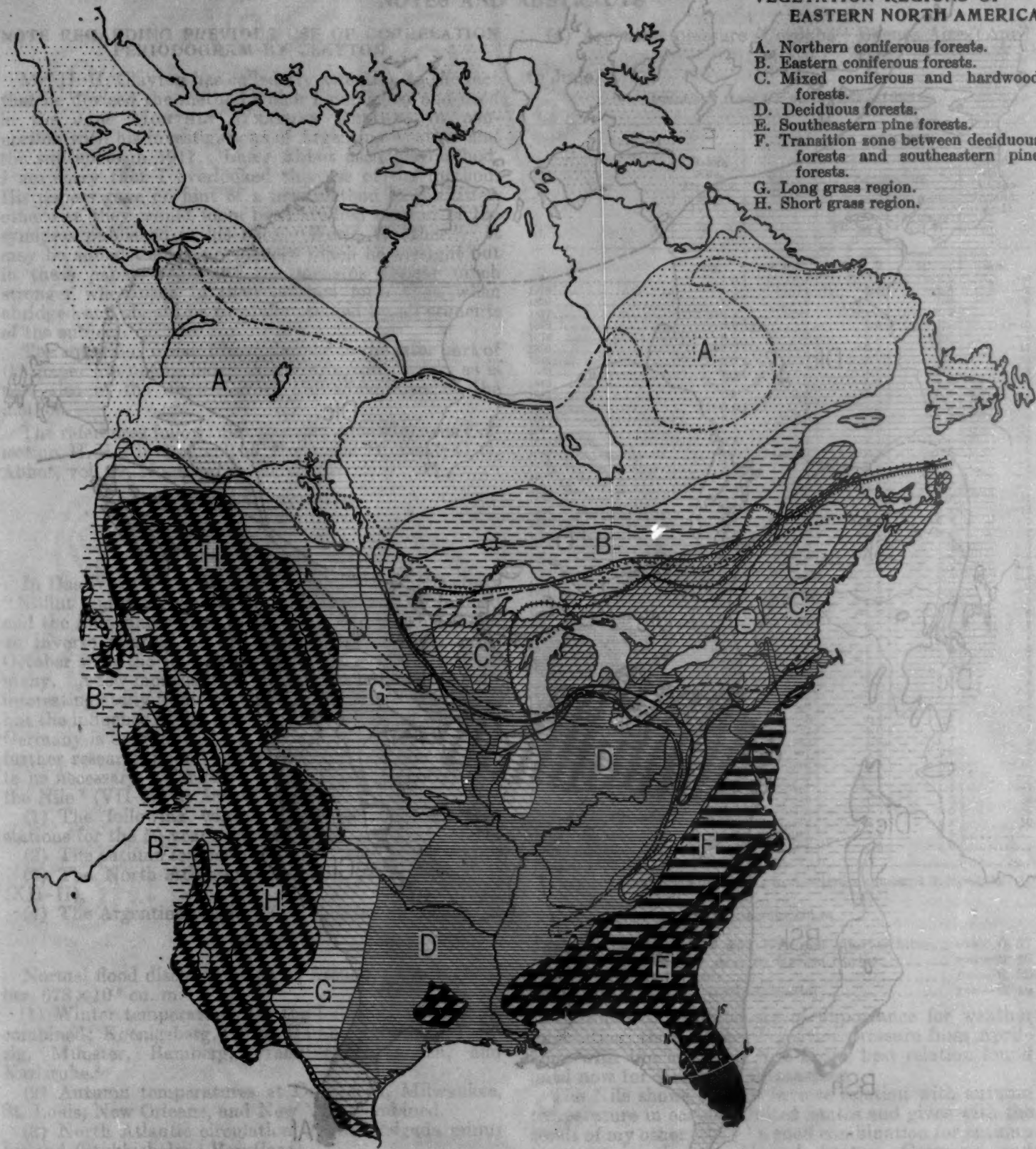
Arrangements have been made with the United States Weather Bureau whereby that organization furnishes the ice patrol with the pressure data for the months October to March, inclusive, and upon which is based the forecast of bergs for the following spring season. The forecast for the ice season of 1926 was "a light ice year" (3.4 on scale 0-10), while as a matter of record it developed that we experienced very closely to "a normal season 4.3." It is fair to add that we were handicapped in making a forecast due to the absence of pressure data from a very critical area, that of Greenland. This difficulty will probably not arise again, as Greenland meteorological stations are now connected with Europe by means of radio.

be used for the distinction between hot and cold steppes and deserts. The mountains.

¹ Owing to the fact that the illustrations in the original article as published in the July Review, pp. 315-319, did not have the proper legends, the two line cuts are reproduced here.—EDITOR.

VEGETATION REGIONS OF
EASTERN NORTH AMERICA

- A. Northern coniferous forests.
- B. Eastern coniferous forests.
- C. Mixed coniferous and hardwood forests.
- D. Deciduous forests.
- E. Southeastern pine forests.
- F. Transition zone between deciduous forests and southeastern pine forests.
- G. Long grass region.
- H. Short grass region.



Northern and southern limit of:
 ——— *Pinus strobus*
 - - - *Tsuga canadensis*
 - - - *Populus balsamifera*
 Southern limit of:
 ——— *Abies balsamea*

Northern limit of:
 ——— *Quercus rubra*
 *Quercus macrocarpa*
 *Fagus americana*
 60—60 Number of evergreen broad
 leaved trees south of line

a. One to four months > 50° F. coldest month > -30° F.
 b. Enough rain or snow in all months.
 c. Steppe climate.
 d. Cold, some months < 50° F.
 e. Hot, coldest month > 50° F.

CLIMATIC REGIONS OF EASTERN NORTH AMERICA
 a. Tropical rainy climate.
 b. Dry climate.
 c. Warm temperate rainy climate.
 d. Subarctic climate.
 e. Snow climate.
 f. Temperature of warmest month > 73° F.



CLIMATIC REGIONS OF EASTERN NORTH AMERICA

- A. Tropical rainy climates.
- B. Dry climates.
- C. Warm temperate rainy climates.
- D. Subarctic climates.
- E. Snow climates.
- a. Temperature of warmest month $> 72^{\circ}$ F.
- b. Temperature of warmest month $< 72^{\circ}$ F., more than four months $> 50^{\circ}$ F.
- c. One to four months $> 50^{\circ}$ F., coldest month $> -36^{\circ}$ F.
- f. Enough rain or snow in all months.
- S. Steppe climate.
- k. Cold; some months $< 50^{\circ}$ F.
- h. Hot; coldest month $> 50^{\circ}$ F.

NOTES AND ABSTRACTS

NOTE REGARDING PREVIOUS USE OF CORRELATION PERIODOGRAM BY CLAYTON

Mr. H. H. Clayton has called my attention to the fact that he devised the method which I published and used in the June MONTHLY WEATHER REVIEW, in connection with his investigations of Argentine weather and the sun spots in 1917. Later Abbot used his method. I am sorry that I overlooked this use of the method. His papers gave no hint of a new method in the titles, otherwise they would have been studied instead of the synopses published in his book "World Weather." It may be added that the evidences which he brought out in these papers regarding relationships appear much stronger when seen in their original form than when abridged and should be carefully studied by all students of the subject.

The equations which I have derived in the later part of the paper are not included in Mr. Clayton's work, as is true also of the discussion of the advantages of the method.

The references follow: Smithsonian Miscellaneous Collection, H. H. Clayton, vol. 68, No. 3, and 71, No. 3; C. G. Abbot, vol. 69, No. 6.—*Dinsmore Alter*.

NILE FLOOD STUDIES

Fred GROISSMAYR,

[Passau, Germany]

In *Das Wetter*, August, 1926, I published a little study "Niflut und der Folgewinter in Deutschland (Nile flood and the following winter in Germany), in which I found an inverse relation of the Nile at Assuan from July-October with the following winter temperatures in Germany. A few months later E. W. Bliss published a very interesting study "The Nile Flood and World Weather," but the influence of the Nile upon the following winter in Germany is only given by a single correlation; therefore further research upon these interesting relations seemed to be necessary. For this purpose I used in correlation the Nile¹ (VII-X) at Assuan with—

- (1) The following winter temperatures at German stations for the 50-year period 1874-1923.
- (2) The autumn temperatures in eastern United States.
- (3) The North Atlantic circulation (Azores-Iceland) (XII-II).
- (4) The Argentine pressure (one quarter earlier).

DATA

Normal flood discharge, Nile at Assuan, July to October, 678×10^9 cu. m.

(1) Winter temperatures for the following 10 stations combined: Koenigsberg, Berlin, Hamburg, Breslau, Leipzig, Münster, Bamberg, Frankfurt, München, and Karlsruhe.²

(2) Autumn temperatures at Cincinnati, Milwaukee, St. Louis, New Orleans, and New York combined.

(3) North Atlantic circulation, Punta Delgada minus Iceland (Stykkisholm + Berufjord).

2

¹ The Nile Flood and World Weather, E. W. Bliss Memoirs, Royal Met. Soc., vol. 1, No. 5, London, 1926.

² Baur in Grundlagen einer Vierteljahrstemperaturvorhersage. Braunschweig, 1926.

(4) Argentine pressure (Cordoba + Buenos Aires) April to June.

Deviations from the mean, 1874-1923

Year	Before Nile, Argentine pressure, IV-VI	Nile, VII-X	After Nile		Circulation, Azores- Iceland, XI-II
			Temperature		
			U. S. A., IX-XI	Germany, XII-II	
	mm.	R. N. ¹	°F.	°C.	mm.
1874	1.3	8	-0.1	-1.6	-6
1875	0.2	4	-3.5	-1.6	-2
1876	0.3	4	-3.1	1.9	0
1877	-0.5	-4	-1.5	0.9	1
1878	-0.3	7	0.0	-1.0	-10
1879	0.1	6	0.5	-3.5	-3
1880	-0.3	2	-2.2	-0.7	-17
1881	-0.2	0	-2.7	1.0	15
1882	0.4	-2	1.3	0.7	3
1883	-0.7	3	-0.2	2.2	9
1884	0.1	-2	1.7	0.5	-1
1885	0.2	2	-1.7	-1.6	-5
1886	0.3	0	-0.2	-1.2	4
1887	-0.5	6	-1.9	-1.3	-11
1888	-0.4	-4	-2.1	-1.8	3
1889	0.3	2	-2.4	-0.6	0
1890	0.6	5	0.2	-3.5	-2
1891	-0.4	2	-0.7	-0.1	-1
1892	2.4	7	-2.1	-2.7	-6
1893	0.7	2	-0.6	0.1	11
1894	1.5	6	-0.4	-3.1	-13
1895	0.8	6	-0.9	-0.4	-2
1896	1.5	4	-1.0	-0.8	0
1897	-0.2	0	2.5	1.6	5
1898	-0.9	4	-0.3	2.6	-4
1899	-0.6	-6	2.0	-0.5	-4
1900	0.7	0	2.3	1.6	-4
1901	-0.8	-1	-0.3	1.1	-6
1902	-1.6	-6	1.9	0.6	6
1903	-0.2	0	-1.2	-0.1	5
1904	0.2	-4	0.3	0.7	1
1905	-1.0	-6	0.3	1.1	7
1906	-0.6	-1	1.0	-1.2	5
1907	0.3	-7	-1.2	0.3	5
1908	0.8	2	1.5	-1.5	4
1909	1.3	2	1.1	2.3	8
1910	0.3	-1	-0.1	1.1	2
1911	0.8	-3	-0.6	1.0	-4
1912	0.2	-5	1.4	1.5	6
1913	-0.6	-12	1.0	0.9	3
1914	-1.5	-3	1.3	1.7	5
1915	-1.4	-7	2.2	2.6	3
1916	0.2	4	-0.2	-1.4	-12
1917	1.2	2	-3.4	0.2	-6
1918	-0.9	-5	-0.6	1.4	-4
1919	-2.0	-3	1.7	2.0	10
1920	-0.2	-3	1.4	2.0	1
1921	-0.3	-4	2.2	-1.2	10
1922	0.2	-1	2.4	1.5	
1923	-0.1	-1	-0.3	-2.6	

¹ 1 R. N. = 33.10^6 cbm., Assuan, VII-X; R. N. = relative number; 1 R. N. = 5%.

CORRELATIONS

Argentine pressure IV-V and Nile one quarter later. $r = 0.57$
 Autumn temperature in eastern United States. $r = -0.40$
 Following German winter. $r = -0.50$
 Circulation in winter (North Atlantic). $r = -0.49$

All these correlations are of importance for weather forecasting; those of the Argentine pressure from April-June with the following Nile is the best relation found until now for Nile flood forecasting.

The Nile shows also an inverse relation with autumn temperature in eastern United States and gives with the result of my other study¹ a good combination for autumn temperatures in the United States. Germany and western Europe winter temperatures are very well inversely related with the Nile second quarter earlier.

¹ MONTHLY WEATHER REVIEW 54:200.

INDIA SEEMS ASSURED OF ANOTHER SATISFACTORY MONSOON

[Reprinted from *COMMERCE REPORTS* of September 26, 1927]

Present indications are that the 1927 monsoon, or rainy season, upon which the prosperity of India depends, will be a successful one, making the sixth successive favorable monsoon for the Empire. A cable received on September 6 from Trade Commissioner C. B. Spofford, Calcutta, states that rainfall to date has been generally normal throughout the greater part of the country.

A slight but not serious deficiency is reported from Bengal, Bihar, Jaipur, Bikaner and the northwest frontier, and a slight excess has fallen in eastern and central Provinces.

SEPTEMBER WEATHER IN THE BRITISH ISLES

[Reprinted from "Nature," October 8, 1927]

September was in most parts of the British Isles an even wetter month than was August, the total rainfall in some places being three times the normal. At Kew Observatory the total was 4.50 inches, compared with 4.06 inches in August. It is interesting to note that the records of rainfall in London since 1812 show that in two previous years—1852 and 1903—a run of wet months began in June. In 1852 the last seven months of the year yielded 28.08 inches, and in 1903, 26.81 inches, whereas the normal for the whole year is between 24 and 25 inches. In neither of these years, nor in any year previous to 1927, did the combined totals for August and September exceed 8 inches; consequently the total of 8.56 inches for the last two months is easily a record since 1812.

The immediate cause of the wet weather in September was the persistence of high atmospheric pressure in the neighborhood of Greenland. This caused frequent cold north or northeast winds over the Arctic Ocean, and these encountered warm southwesterly winds brought up from low latitudes round the anticyclone between the Azores and Bermuda. Such winds carry with them much moisture, especially in early autumn, and the interplay of the two currents resulted in the formation of numerous depressions, which were carried eastward across the British Isles by the upper winds from the west that prevail in temperate latitudes when there is a steep gradient of temperature from south to north. Moreover, the persistence of high pressure in the far north tended to prevent Atlantic depressions from wandering up into higher latitudes, and so allowing the Azores anticyclone to make those periodical excursions northeastward which are responsible for so many of our spells of dry sunny weather.

WEATHER IN VARIOUS PARTS OF THE WORLD AS AFFECTING TRADE

Cable reviews to Commerce Reports

September 26, 1927, Argentina.—Crop conditions in Argentina so far are favorable, but lack of need rain is causing some concern.

Australia.—Agricultural and pastoral conditions in western Australia are reported excellent. Some rain has fallen in South Australia, improving the agricultural outlook for that State, but pastoral regions are suffering yet. Conditions are fair in Victoria, but in New South Wales drought over the larger part of the State is causing important sheep losses.

Hawaii.—Heavy rainfalls and high temperatures have continued unusually favorable to the growth of crops in Hawaii.

Europe.—The frequent rains have retarded harvesting and considerable damage has been done to the late oat and wheat crops. The outlook for sugar beets is excellent, provided cold weather does not set in.

METEOROLOGICAL SUMMARY FOR BRAZIL, AUGUST, 1927

By J. DE SAMPAIO FERRAZ, Director

[Directoria de Meteorologia, Rio de Janeiro]

Six anticyclones crossed the southern part of the continent, and between their irruptions, high-latitude lows and the continental depression were very active. Weather was generally very unstable and several gales were registered in the southern coast up to Rio. Low-pressure systems were specially vigorous in the second week of the month. The fourth high was particularly intense, and appeared on the 21st with a spell of cold weather and high winds. The fifth anticyclone moved rapidly to the northeast and was absorbed by the previous high. All the high-pressure systems followed practically the northeast direction, which is rather irregular for the last month of winter.

Rainfall distribution was well under normal in the northern section of the country. In the center and south precipitation was very irregular as would be expected.

Crops generally doing well, and this year's big coffee harvest is almost ended. All over the country soil is being prepared for cane, tobacco, cereals and vegetables; wheat and the last two already being planted.

Rio's pressure was 1.7 millibars under normal, and temperature 0.1° C. below normal. Weather constantly unsettled. Two gales were registered, on the 4th and 13th. The last one reached 30 meters per second in the evening.

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING SEPTEMBER, 1927

By HERBERT H. KIMNALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, 52:42, January, 1925, 53:20, and July, 1925, 53:318.

Table 1 shows that solar radiation intensities were above the normal values for September at Washington, D. C., and Madison, Wis., and close to normal at Lincoln, Nebr. At the latter station a noon intensity on the 20th of 1.48 gram-calories per minute cm^2 equals the previous maximum intensity obtained at that station in September.

Table 2 shows an excess at Washington and Lincoln in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky, and a deficiency at Madison, as compared with the September normals for these stations.

Skylight polarization measurements at Washington made on six days give a mean of 53 per cent, with a maximum of 60 per cent on the 12th. At Madison measurements on three days give a mean of 69 per cent with a maximum of 73 per cent on the 23d. These are close to normal values for September at Madison and considerably below at Washington.

TABLE 1.—Solar radiation intensities during September, 1927

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance										Local mean solar
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	
	Air mass										
	A. M.					P. M.					
78th mar. time	a.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	a.
Sept. 6.	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Sept. 12.	11.81	0.80	0.84	0.96	1.10	1.27	1.00	0.87	0.74	0.58	10.21
Sept. 19.	9.83	0.87	0.94	1.09	1.29	1.47	1.20	1.06	0.93	0.80	9.14
Sept. 20.	8.48	0.60	0.82	1.00	1.10	1.27	1.00	0.87	0.74	0.58	7.04
Sept. 22.	6.50	0.60	0.74	0.87	1.12	1.39	1.00	0.87	0.74	0.58	7.29
Sept. 23.	6.70	0.60	0.74	0.87	1.12	1.38	1.00	0.87	0.74	0.58	5.56
Sept. 24.	7.29	0.60	0.74	0.87	1.12	1.45	1.00	0.87	0.74	0.58	5.79
Sept. 27.	10.21	0.60	0.74	0.87	1.08	1.23	1.00	0.87	0.74	0.58	10.97
Means		0.79	0.84	0.94	1.13	1.27	(1.10)	(0.96)	(0.84)	(0.66)	
Departures		+0.09	+0.09	+0.07	+0.05	+0.05	+0.05	+0.11	+0.11	+0.19	

Madison, Wis.

	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Sept. 3.	11.38	0.80	0.84	0.96	1.10	1.27	1.00	0.87	0.74	0.58	9.47
Sept. 14.	16.20	0.87	0.94	1.09	1.47	1.30	1.00	0.93	0.80	0.68	16.20
Sept. 19.	5.36	0.60	0.82	1.00	1.10	1.27	1.00	0.87	0.74	0.58	4.95
Sept. 21.	6.27	0.60	0.82	1.00	1.10	1.27	1.00	0.87	0.74	0.58	6.50
Sept. 23.	6.02	0.60	0.82	1.00	1.10	1.27	1.00	0.87	0.74	0.58	6.27
Means		0.79	0.84	0.94	1.13	1.27	(1.10)	(0.96)	(0.84)	(0.66)	
Departures		+0.09	+0.09	+0.07	+0.05	+0.05	+0.05	+0.11	+0.11	+0.19	

TABLE 1.—Solar radiation intensities during September, 1927—Con.

Lincoln, Nebr.

Sun's zenith distance												
8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.6°	78.7°	Noon		
Date	75th mer. time	Air mass										Local mean solar
		A. M.					P. M.					
		0.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0		e.
Sept. 2.	mm.	cal.	cal.	cal.	cal.	cal.	1.38	1.13	0.95	0.77	0.65	12.24
Sept. 3.	15.05			0.84								12.24
Sept. 5.	16.70		0.71	0.88	1.09							15.65
Sept. 8.	17.37					1.40	1.12	0.94	0.80	0.71		17.96
Sept. 9.	17.37		0.84	0.98	1.14	1.39	1.11	0.96	0.82	0.68		16.79
Sept. 10.	15.11	0.65	1.77	0.92	1.12	1.32						14.10
Sept. 12.	14.10						1.10	0.84	0.67			13.13
Sept. 13.	15.05		0.84	0.90	1.15	1.36						14.10
Sept. 14.	15.11			0.90		1.38	1.14					16.20
Sept. 16.	18.80		0.67	0.90	1.14	1.34	1.10	0.87	0.80			17.37
Sept. 17.	16.20		0.90	1.01								14.10
Sept. 20.	4.95		1.15	1.23	1.40	1.63	1.40	1.19	1.04	0.94		3.63
Sept. 21.	4.95				1.57							3.81
Sept. 22.	5.79						1.15	1.08				5.16
Sept. 23.	6.76				1.24							6.50
Means		(0.65)	0.57	0.99	1.21	1.39	1.16	0.97	0.82	0.74		
Departures		-0.10	+0.00	-0.02	+0.02	-0.01	+0.01	-0.01	-0.01	+0.01		

* Extrapolated.

TABLE 2.—Solar and sky radiation received on a horizontal surface

[Gram-calories per square centimeter of horizontal surface]

Week beginning	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1927	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Sept. 3	400	346	470	347	390	499	+15	-10	+39
10	362	351	458	328	322	484	-11	+6	+58
17	367	356	480	273	276	503	+12	+27	+97
24	382	128	156	130	285	328	+42	-150	-182
Deficiency since first of year on Sept. 30.							-8,484	-4,361	-7,049

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory]

[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson observatories]

Date	Eastern standard civil time	Heliographic		Area ¹	
		Longitude	Latitude	Spot	Group
1927	A. M.	°	°		
Sept. 1 (Yerkes)	9 59	-53.0	-12.0	200	
		-45.0	-12.0	180	
		-10.0	-16.0		100
		-48.0	-16.0	100	
		-53.0	-17.0	100	
Sept. 2 (Naval Observatory)	11 31	-31.5	-14.5		108
		-31.5	-14.5		92
		-43.5	-17.0		123
		-67.0	-17.5		278
Sept. 3 (Naval Observatory)	11 38	-25.0	-16.5		108
		-17.5	-16.5		77
		+16.0	-17.5		123

¹ Areas are corrected for foreshortening and are expressed in millionths of Sun's visible hemisphere.

Date		Eastern standard civil time	Heliographic		Area	
			Longitude	Latitude	Spot	Group
1927		A. M.	°	°		
Sept. 4 (Naval Observatory)		11 40	-75.0	-12.0		216
			-11.5	-16.5		77
			-3.5	-14.5		62
			+29.5	-17.5		139
Sept. 5 (Naval Observatory)		11 42	-61.5	-11.5		216
			+2.0	-16.0		77
			+10.0	-14.5	62	
			+43.0	-17.5		93
Sept. 6 (Naval Observatory)		11 43	-77.5	+10.5		62
			-47.5	-11.0		185
			+17.0	-17.5		46
			+23.0	-15.0		62
			+53.5	-18.5	77	
Sept. 7 (Naval Observatory)		11 44	-64.0	+20.0		15
			-33.5	-11.0		185
			+28.0	-10.0		31
			+36.5	-14.5		62
			+67.5	-18.0	77	
Sept. 8 (Harvard)		9 38	-67.5	-18.0		61
			-18.0	-10.0		455
			+48.5	-13.5	121	
Sept. 9 (Harvard)		10 15	-6.5	-9.5		424
Sept. 10 (Mount Wilson)		13 5	-35.0	-8.0		72
			-10.0	-16.0		12
			+7.0	-10.0		224
Sept. 11 (Naval Observatory)		11 35	-37.0	-20.0		216
			-34.0	-12.0		31
			-24.0	-8.5		62
			+18.5	-14.0		46
			+19.5	-10.0	134	
			+48.0	+17.0		62
Sept. 12 (Naval Observatory)		11 44	-71.0	-12.0		123
			-22.5	-20.0		401
			-17.5	-12.0		108
			+31.5	-17.0		31
			+33.0	-10.5	123	
Sept. 13 (Naval Observatory)		11 52	-77.0	+21.5		216
			-56.5	-11.0		154
			-8.0	-20.0		617
			-4.5	-12.0		216
			+47.0	-10.0	123	
Sept. 14 (Naval Observatory)		12 5	-63.0	-10.0	154	
			-63.0	+21.5		154
			-43.5	-11.5		108
			-16.5	-19.5		15
			+5.0	-20.0		710
			+9.5	-12.0		470
			+60.5	-10.0	123	
Sept. 15 (Naval Observatory)		11 46	-53.0	-13.5	309	
			-60.5	-10.0	93	
			-55.0	+23.0		31
			-50.0	+21.0		154
			-34.0	-12.5		62
			-26.5	-11.0		46
			-0.5	-19.5		15
			+10.5	+25.0		15
			+17.5	-20.0		710
			+24.0	-12.0		556
			+74.0	-10.0	123	
Sept. 16 (Naval Observatory)		12 9	-69.0	-14.5	154	
			-57.0	-10.0	62	
			-44.0	+25.0	15	
			-38.0	+21.0		139
			-20.0	-13.0	31	
			-12.0	-10.0		15
			+8.0	-14.0		31
			+14.0	-19.5		31
			+31.0	-20.0		741
			+37.0	-12.0		648
			+82.0	+17.0		154
Sept. 17 (Yerkes)		10 25	-54.0	-14.0	50	
			-23.0	+21.0	150	
			+38.0	-19.0	400	
			+48.0	-17.0	200	
			+54.0	-10.0	300	
Sept. 18 (Naval Observatory)		11 33	-42.0	-14.0	123	
			-29.0	-10.0	15	
			-11.0	+21.0		154
			+2.0	-11.0		46
			+15.0	-10.5		15
			+51.0	-22.0		278
			+62.0	-19.0	370	
			+64.0	-12.0		710
Sept. 19 (Yerkes)		11 34	-29.0	-13.0	50	
			+3.0	+21.0	150	
			+65.0	-21.0	200	
			+80.0	-12.0	400	
			+80.0	-19.0	200	
Sept. 20 (Naval Observatory)		11 46	-73.5	+14.5		31
			-63.5	+14.0	15	
			-57.0	-18.5		31
			-23.0	+11.0		31
			-17.0	-14.0	93	
			+12.5	+21.5		154
			+34.5	-11.5		62
			+76.0	-22.0	403	
Sept. 21 (Naval Observatory)		11 46	-50.0	+14.0		6
			-41.0	-13.0	3	
			-4.0	-13.0		123
			+28.0	+21.5		130
Sept. 22 (Naval Observatory)		11 50	-73.0	-10.0	185	
			-37.0	+14.0	9	
			-3.0	+10.5		31
			+19.5	-13.0	46	
			+21.0	-21.0		62

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Date	Eastern standard civil time	Heliographic		Area	
		Longitude	Latitude	Spot	Group
1927					
Sept. 22 (Naval Observatory).....	11 50	+41.0	+21.5	123	
		+62.0	-11.5	16	
Sept. 23 (Naval Observatory).....	11 47	-59.5	-19.0	185	
		+10.0	+10.5		62
		+23.0	-13.0	46	
		+32.5	-17.0		31
		+33.0	+21.0		93
		+53.5	+21.5	123	
Sept. 24 (Naval Observatory).....	11 43	-46.0	-19.0	216	
		+13.5	+5.0		31
		+24.0	+10.5		62
		+37.0	-12.5		31
		+46.0	-17.0		108
		+46.5	+21.0		123
		+68.0	+21.0	123	
Sept. 25 (Naval Observatory).....	11 44	-53.5	+18.5	15	
		-32.5	-18.5	185	
		+29.0	+6.0	15	
		+37.5	+11.0		62
		+56.0	-17.5		108
		+60.0	+21.0		154
		+62.0	-15.0	93	
		+82.0	+21.0	108	
Sept. 26 (Naval Observatory).....	11 43	-70.0	-12.5	6	
		-39.0	+17.5	19	
		-19.0	-19.0	170	
		+42.5	+6.0	15	
		+61.0	+10.5		62
		+69.0	-18.0		185
		+75.0	-15.0		108
Sept. 27 (Naval Observatory).....	11 46	-66.0	-11.5		31
		-32.0	-19.5		31
		-25.0	+18.0	15	
		-6.0	-18.5		185
		+67.0	+6.0	6	
		+66.5	+10.5		46
Sept. 28 (Naval Observatory).....	11 34	-42.0	-12.5		31
		-41.5	-34.0	3	
		-12.0	+18.0	9	
		+7.5	-18.5		196
Sept. 29 (Naval Observatory).....	12 9	-64.0	+21.0		31
		-28.0	-33.0	6	
		-32.5	-12.0		31
		+19.5	-18.5		185
Sept. 30 (Naval Observatory).....	11 45	+52.0	-18.0	15	
		+49.5	+20.5		31
		+32.0	-18.5		185

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR 1927, JANUARY TO SEPTEMBER, INCLUSIVE¹

(Data supplied by Prof. A. Wöller, Zurich, Switzerland, October, 1927)

1927	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1		130	41	76	48	32	98	49	61
2		136	46	91	53	42	120	50	61
3	65	157	46	88	68	41	101	85	52
4		155	67	77	73		111	60	26
5	89	173	59		99	51	97	61	50
6	78		57	98	105	63	73	46	44
7		163	71	97	97	79	61	37	47
8	108	116			78	79	45	17	40
9		127	91	136	91	57	54	18	44
10		124	45		110	54		19	47
11	124	106	54	163	101	63	42	32	67
12		82	40	137	143	72	16	21	31
13	54	58		125	97	73	14	53	96
14	70	98	60	138	57	54	32	59	103
15	71	71		129	89	32	32	70	184
16		88	95	157	67	23	44	68	124
17		125	124	87	51	47	80	109	
18	114		126	120	99		45	97	
19		65	147	91	67	35	22	79	
20		67	113	66	73	26	34	58	79
21		467	131	59	81	32	43	49	54
22	80	57	121	67	87	43	49	60	44
23	95	53	82	62	68	45	49		72
24		45	56	45	101	64	55		
25	44	54	49	50	91	71	68	55	
26		50	23	90	86	88	68	56	56
27	83	79			88	81	75	68	77
28	49	64	16	397	43	116	34	52	38
29	64		31	85	68	114	68		27
30	109		16	48	34	113	39	66	
31	149		21		28		43	56	
Mean	70.1	93.1	68.4	93.1	70.3	60.5	55.4	52.8	67.5
Number of observations	19	25	27	28	31	28	29	29	26

¹ For sunspot values for 1926, see REVIEW for July, 1926, and January, 1927, pp. 300 and 30, respectively.—Editor.

CORRECTED SOLAR-CONSTANT VALUES, MONTEZUMA, CHILE, FROM MAY 27 TO AUGUST 24, 1927, INCLUSIVE

(Corrections furnished by Dr. C. G. Abbot, Assistant Secretary, Smithsonian Institution, Washington, Oct. 28, 1927)

Due to an error in computing at the Montezuma station, the solar-constant values, telegraphed and published on the daily Washington Weather Map for the above period, should be discarded and the following substituted:

	May ¹	June ¹	July ¹	August ¹
1		1.937 S.—	1.930 S.	1.940 S.
2		1.931 S.	1.932 S.	1.945 S.
3		1.939 S.—	(²)	1.940 S.
4		1.931 S.	(²)	1.940 S.
5		1.933 S.	1.935 S.—	1.942 S.
6		(²)	(²)	1.942 S.
7		1.935 S.	1.921 U.	1.946 S.
8		1.930 S.	1.924 S.	(²)
9		1.929 S.	(²)	1.940 S.
10		1.927 S.	1.936 S.	1.941 S.
11		1.929 S.	1.931 S.	1.934 S.—
12		1.927 S.	(²)	(²)
13		1.935 S.	1.924 S.	(²)
14		1.931 S.	1.930 S.	1.938 S.
15		1.924 S.	1.927 S.	1.947 S.
16		1.935 S.—	1.928 S.	1.943 S.
17		(²)	1.933 S.	1.943 S.
18		(²)	1.931 S.	1.947 S.
19		(²)	1.930 S.	1.933 S.
20		(²)	1.933 S.	1.942 S.

	May	June	July	August
21		(²)	1.933 S.	1.931 S.
22		1.932 S.—	1.925 S.	1.934 S.
23		1.925 S.	1.931 S.	1.932 S.
24		1.924 S.	1.924 S.	1.935 S.
25		1.927 S.	1.932 S.	
26		1.929 S.	1.950 S.—	
27	1.930 S.	1.925 S.	1.947 S.	
28	1.923 S.	1.929 S.	1.945 S.	
29	1.934 S.	1.927 S.—	1.937 S.	
30	1.926 S.	1.927 S.	1.945 S.	
31	1.922 S.		1.944 S.	

CORRECTED DECADE MEANS

	May	June	July	August
1-10		1.932	1.931	1.942
11-20		1.930	1.930	1.941
21-31	1.926	1.927	1.945	1.941

¹ Values from and after July 24 are reduced by the new definitive method. Earlier values are provisional and average 0.014 calories lower. The decade mean July 21-31 has been corrected to the definitive scale.

² Cloudy.

³ Too dry to reduce.

AEROLOGICAL OBSERVATIONS

By W. R. STEVENS

Free-air temperatures for September were near normal at all aerological stations. There was a tendency, however, toward positive departures, except at Ellendale and Groesbeck, the latter station having negative departures at all observed levels.

Relative humidities were slightly above normal at Broken Arrow and Royal Center, and slightly below at Due West, Groesbeck, and Washington.

Vapor-pressure departures were unimportant.

In general, resultant winds were near normal; at Ellendale, however, an easterly component prevailed in the lower levels where normally there is a westerly component. Winds of southerly component prevailed quite generally up to an altitude of 1,500 meters over most of the United States, except in the Atlantic and East Gulf States and in certain regions of the Pacific Coast States. At 3,000 and 4,000 meters winds of southerly component were general west of the Mississippi River and winds of northerly component to the east. The month was quite notably free of winds of high velocity, even at Rocky Mountain stations.

A single-theodolite pilot balloon observation was made at Groesbeck on the afternoon of the 14th to an altitude of 18 km. While the occurrence of squalls soon after the completion of the ascent prevented verification, there seems, however, to be no doubt as to its accuracy. The wind velocity varied between 1 and 9 m. p. s. to an altitude of 14 km., the highest velocity, 15 m. p. s., being at 17.5 km. The direction turned with altitude from SE. at the surface, through W, N, E., and finally to SE. again, a complete turning of 360°.

The kite flights at Ellendale on the 17th and 18th and at Royal Center on the 18th and 19th are of considerable interest inasmuch as they depict conditions before and after the passage of a cold front. In neither case did the greatest fall in temperature occur at the surface. At Ellendale the greatest fall, 17.1° C., occurred at 900 meters m. s. l., or about 450 meters above the surface. At Royal Center the greatest fall, 16.0° C., appeared at 1,900 meters m. s. l., or about 1,700 meters above the surface. The above facts point to the possibility that, as a high moves farther and farther to the east or south, the greatest fall in temperature takes place at higher and

higher altitudes as a result of more rapid heating of the surface-air layers than of those aloft.

Two excellent observations were obtained in the center of an area of high pressure on the 25th and 26th at the Naval Air Station at Washington. Observations under these conditions are comparatively rare since kite flights can not ordinarily be made when the crest of the high is over the station. The free-air conditions on these dates are shown in the following table:

25th					26th				
Time	Altitude	Temperature	Humidity		Time	Altitude	Temperature	Humidity	
			Relative	Vapor pressure				Relative	Vapor pressure
	Meters	° C.	%	mb.		Meters	° C.	%	mb.
9:22 a. m.	7	22.1	51	13.58	8:23 a. m.	7	13.0	79	13.48
	250	19.9	47	10.93		250	14.1	77	12.39
	500	17.6	43	8.66		500	13.0	73	10.94
	750	16.5	37	6.95		750	12.5	64	9.28
	1,000	15.4	32	5.90		1,000	12.8	51	7.54
	1,250	14.2	26	4.21		1,250	13.1	37	6.88
	1,500	13.0	22	3.30		1,500	13.4	24	3.69
	2,000	10.3	16	2.00		2,000	12.7	10	1.47
	2,500	10.0	8	0.98		2,500	10.2	6	0.75
	3,000	7.9	2	0.21		3,000	7.7	3	0.21

It is of interest to investigate the free-air observations in relation to the tornado that occurred at St. Louis on the 29th. On the morning of this date a low of considerable intensity was centered over eastern Nebraska and Kansas—Concordia, 29.34 inches. This low had developed over Wyoming during the previous day as a secondary to a disturbance centered over Alberta. The aerological chart shows a current of warm, humid, southerly air flowing rapidly up the Mississippi Valley with a SW. wind at higher altitudes. Farther to the west there was a WNW. wind aloft. It seems probable from the few observations available that the WNW. wind overran the warm, moist Gulf air producing a cold front aloft at which violent convection would take place. The kite flight at Royal Center, about 300 miles northeast of St. Louis, on the morning of the 29th is indicative of the potential instability existing over the Middle West, the lapse rate of 0.70 for the layer 2,145–2,897 meters being superadiabatic for moist air.

* Naval Air Station, D. C.

8—72—82707

Meteorological conditions over Royal Center, Ind., on September 29, 1927

Time	Altitude	Temperature	Δt 100 m.	Relative humidity	Wind	
					Direction	Velocity
m.	Meters	°C.		Per cent		m.p.h.
6:14	225	17.8		97	S	2.1
6:35	792	15.6	0.29	96	S	21.1
6:40	1,108	14.2	0.44	82	SSW	21.3
6:52	1,525	12.5	0.41	91	SSW	19.6
7:07	2,145	10.2	0.37	52	SSW	21.6
7:35	2,897	4.9	0.70	100	SSW	23.8

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during September, 1927

Altitude (m.)	Broken Arrow, Okla. (233m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444 m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)		Washington, D. C. (7m.)	
	Mean		Mean		Mean		Mean		Mean		Mean	
	Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean	
M. S. L.												
Surface	22.3	-1.2	23.7	-0.2	15.0	+0.3	23.0	-1.4	20.1	-0.8	23.3	+1.7
250	22.2	-1.2	23.4	-0.1			22.5	-1.3	20.0	-0.7	21.6	+1.3
500	21.4	-0.5	21.4	+0.2	14.9	+0.2	21.0	-0.7	19.5	-0.7	19.9	-0.8
750	20.6	-0.1	20.3	-0.6	14.1	+0.1	20.5	-0.4	18.2	-0.9	18.7	-0.7
1,000	19.7	+0.3	19.1	-0.5	12.9	-0.2	19.2	-0.5	16.7	-0.9	17.8	-0.7
1,250	18.6	-0.5	17.7	-0.4	11.8	-0.4	18.4	-0.1	14.9	-0.6	16.6	-0.5
1,500	17.4	-0.5	16.4	-0.4	10.5	-0.6	17.2	-0.2	13.1	-0.2	15.4	+0.4
2,000	14.8	-0.5	14.4	+1.0	8.2	-0.4	14.3	-0.7	10.0	-0.9	12.6	-0.3
2,500	11.8	-0.4	11.7	-1.1	5.3	-0.5	12.3	-0.3	7.2	-0.3	10.8	0.0
3,000	8.8	+0.3	9.0	-1.7	1.7	-1.1	9.7	-0.5	3.3	+0.2	9.0	+0.8
3,500	6.4	+0.9	8.9	-3.4	-1.5	-1.5	6.7	-1.0	2.8	+0.4	6.4	+1.1
4,000	3.8	-1.3	7.5	-4.7	-5.5	-2.7	3.4	-1.5	0.3	-0.3	6.4	+1.1
4,500	1.3	+1.6	6.4	-6.3	-9.2	-3.0			-2.1	+0.5		
5,000												

TABLE 2.—Free-air resultant winds (m. p. s.) during September, 1927

Altitude (m.)	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		10-year mean		Mean		7-year mean		Mean		10-year mean		Mean		9-year mean		Mean		10-year mean		Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 4°E.	3.2	South.	3.3	N. 48°E.	2.3	N. 59°E.	2.7	N. 10°E.	0.5	N. 76°W.	0.4	S. 30°E.	2.2	S. 18°E.	1.8	S. 40°W.	2.0	S. 42°W.	1.4	N. 32°W.	0.4	N. 1°W.	0.7
250	S. 3°E.	3.3	South.	3.4	N. 49°E.	2.6	N. 58°E.	2.6	N. 10°E.	0.5	N. 76°W.	0.5	S. 30°E.	2.4	S. 18°E.	2.5	S. 38°W.	2.4	S. 42°W.	1.6	N. 35°W.	0.9	N. 15°W.	1.0
500	S. 4°W.	4.3	S. 7°W.	4.8	N. 41°E.	3.2	N. 64°E.	2.9	N. 7°E.	0.4	S. 65°W.	0.5	S. 30°E.	3.4	S. 18°E.	2.5	S. 46°W.	3.3	S. 46°W.	2.6	N. 35°W.	1.0	N. 15°W.	1.2
750	S. 5°W.	6.6	S. 15°W.	5.0	N. 43°E.	3.5	N. 60°E.	3.4	N. 25°E.	0.5	S. 52°W.	1.1	S. 3°W.	4.9	S. 4°E.	4.1	S. 51°W.	5.9	S. 54°W.	4.3	N. 64°W.	1.8	N. 38°W.	1.5
1,000	S. 14°W.	7.0	S. 23°W.	5.4	N. 48°E.	3.0	N. 66°E.	3.2	N. 26°W.	0.8	S. 56°W.	1.8	S. 3°W.	4.9	S. 7°E.	4.7	S. 56°W.	7.2	S. 63°W.	5.1	N. 68°W.	2.1	N. 42°W.	2.6
1,250	S. 22°W.	7.3	S. 30°W.	5.3	N. 55°E.	3.0	N. 64°E.	3.1	S. 75°W.	1.0	S. 56°W.	2.6	S. 12°W.	5.0	South.	4.8	S. 60°W.	8.1	S. 65°W.	6.1	N. 57°W.	3.4	N. 54°W.	4.1
1,500	S. 25°W.	6.9	S. 38°W.	5.5	N. 50°E.	3.0	N. 55°E.	2.4	S. 84°W.	1.8	S. 67°W.	3.4	S. 8°W.	5.0	South.	4.7	S. 60°W.	8.6	S. 72°W.	6.3	N. 57°W.	3.4	N. 54°W.	4.1
2,000	S. 35°W.	6.8	S. 44°W.	5.8	N. 51°E.	2.9	N. 62°E.	2.2	S. 81°W.	3.7	S. 72°W.	4.8	S. 1°E.	5.9	1°W.	4.4	S. 63°W.	9.0	S. 73°W.	6.8	N. 57°W.	3.4	N. 54°W.	4.1
2,500	S. 40°W.	6.4	S. 51°W.	5.6	N. 40°E.	3.4	N. 59°E.	1.8	N. 86°W.	6.1	S. 78°W.	8.0	S. 3°W.	5.5	1°E.	4.2	S. 60°W.	10.6	S. 73°W.	10.3	N. 53°W.	7.3	N. 70°W.	6.2
3,000	S. 43°W.	6.2	S. 46°W.	5.6	N. 28°E.	6.9	N. 37°E.	0.8	S. 78°W.	7.7	S. 85°W.	8.0	S. 31°E.	3.7	1°E.	4.2	S. 60°W.	12.4	S. 72°W.	12.8	S. 85°W.	6.5	N. 69°W.	6.7
3,500	S. 52°W.	6.7	S. 51°W.	6.3	N. 22°E.	10.0	N. 32°E.	2.5	S. 78°W.	13.1	S. 86°W.	10.6	S. 33°E.	3.5	2°W.	3.4	S. 63°W.	13.0	S. 77°W.	12.4	N. 85°W.	5.8	N. 69°W.	7.0
4,000	S. 70°W.	6.8	S. 68°W.	7.5	North.	13.0	N. 12°W.	3.3	S. 38°W.	16.4	N. 84°W.	11.8	South.	3.0	South.	3.2	S. 69°W.	12.9	S. 85°W.	11.1	West.	6.8	N. 70°W.	7.8
4,500	S. 83°W.	6.4	S. 67°W.	9.1					S. 45°W.	18.0	N. 81°W.	15.0					S. 69°W.	10.3	S. 83°W.	9.6	N. 83°W.	6.7	N. 69°W.	7.9
5,000	South.	11.0	S. 71°W.	9.1													S. 84°W.	7.6	N. 70°W.	7.8				

Comparison with the average pressure for the preceding month is shown on the inset to Chart II of this Review. Under the atmospheric pressure conditions existing during much of the month from the Great Plains eastward, save that they were frequently from northeast to east over the South Atlantic and East Gulf States. West of the Rocky Mountains they were locally from the northwest over the Pacific coast districts from southerly points in portions of the Plateau, and variable elsewhere. Details regarding the severe storms of the month, which were comparatively infrequent save in portions of the upper Mississippi Valley and nearby areas on the 29th, appear in the tables at the end of this section.

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during September, 1927—Continued

Altitude (m.)	Broken Arrow, Okla. (233m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444 m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)		Washington, D. C. (7m.)	
	Mean		Mean		Mean		Mean		Mean		Mean	
	Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean		Departure from 10-yr. mean	
M. S. L.												
Surface	73	+5	66	0	69	0	74	-2	69	+1	66	-9
250	73	+5	66	0			74	-2	69	+1	66	-8
500	67	-1	67	-2			75	-1	65	-3	68	-6
750	67	-1	64	-5			73	-2	65	-2	66	-3
1,000	64	-1	64	-5			61	-1	65	-2	62	-3
1,250	67	-5	68	-1			61	+2	66	0	60	-8
1,500	68	-8	71	+1			60	-1	66	+1	59	-9
2,000	62	-7	64	-2			57	-3	63	+3	58	-4
2,500	60	-9	58	-6			55	-1	61	+4	46	-7
3,000	59	-10	54	-7			61	-3	58	+5	42	-7
3,500	64	-5	42	-13			53	-6	59	+9	41	-1
4,000	49	-2	39	-19			57	+9	55	+9		
4,500	51	-4	30	-21			43	-3	57	+17		
5,000												

VAPOR PRESSURE (mb)

Surface	20.27	+0.45	19.78	+0.37	12.60	+1.14	21.29	-1.95	16.77	-0.04	20.06	-0.12
250	20.11	+0.42	19.49	-0.37			20.86	-1.64	16.58	-0.02	18.19	-0.25
500	17.81	+0.05	17.63	+0.31	12.37	+1.06	19.89	-0.81	15.28	-0.37	16.55	-0.27
750	15.93	-0.10	15.69	-0.14	10.92	-0.67	17.77	-1.02	14.46	-0.75	14.79	-0.47
1,000	15.15	+0.17	14.66	-0.10	9.84	-0.55	16.45	-1.16	12.94	-0.49	13.41	-0.76
1,250	14.64	+1.25	14.27	+0.54	9.09	-0.75	12.90	-1.60	12.10	-0.82	12.14	-0.70
1,500	13.76	+1.57	13.77	-0.92	8.18	-0.70	11.45	-1.51	11.05	-0.95	11.16	-0.67
2,000	10.62	+1.55	11.35	-0.73	6.91	-0.81	8.75	-1.33	8.90	-0.98	9.43	-0.10
2,500	8.38	+1.61	9.34	-0.57	5.46	-0.42	7.31	-0.49	7.25	-1.13	6.90	-0.39
3,000	6.82	+1.76	8.23	-0.80	4.63	-0.37	5.70	-0.38	5.90	-1.34	5.87	-0.02
3,500	5.40	+1.30	6.90	-0.54	2.76	-0.69	4.33	-0.49	5.02	-1.68	4.51	+0.04
4,000	4.14	+1.10	6.28	-0.38	1.68	-1.13	3.07	-0.61	3.80	-1.47		
4,500	3.58	+1.14	5.84	-0.38	0.30	-1.95			3.09	+1.17		
5,000												

* Naval Air Station, D. C.

On the 18th there was considerable precipitation over a narrow belt from Arizona northward to the upper Lake region, and during the following two days the precipitation area extended into portions of the eastern States, the falls becoming heavier and more general over the Atlantic Coast States.

WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

From the agricultural viewpoint the outstanding feature of the month was the return of higher temperatures in the great interior valleys and the resulting gain in the quantity of corn that will be realized from the 1927 planting. The usual details are presented in the text and charts which follow. *A. J. H.*

CYCLONES AND ANTICYCLONES

Low-pressure areas were more numerous than usual, 22 being of sufficient importance to track. There were one or possibly two which might be classed as tropical disturbances, but nothing resembling a hurricane west of Bermuda.

Eight high-pressure areas were plotted, but these were important only during the second half of the month, when two energetic HIGHS pushed southeastward from Alaska and northwest Canada.—*W. P. Day.*

THE WEATHER ELEMENTS

By P. C. DAY

PRESSURE AND WINDS

The marked feature of the weather for September, 1927, was the general redistribution of the pressure conditions whereby the cool weather prevailing almost continuously during the preceding month over most interior and eastern districts was largely reversed in the first two decades of September. During this period atmospheric pressures were in the main comparatively low along the northern border and higher to the southward, with resulting southerly winds and warm weather over nearly all districts from the Rocky Mountains eastward. In addition to this may be mentioned the marked depression of the barometer attending a cyclone that moved from Kansas and Nebraska northeasterly toward the upper Lakes on the 29th, during the early afternoon on which date a destructive tornado occurred at St. Louis, Mo., and some near-by localities, the dull details of which appear elsewhere in this REVIEW.

During the greater part of the first two decades the cyclonic circulation was weak and few low-pressure areas extended into the central valleys or to the eastward and but little precipitation occurred, except locally along the Atlantic coast on the 1st and 2d, in connection with the northward movement of a barometric depression that appeared off the middle Atlantic coast on the 1st and later moved inland over New England, giving some heavy rains over eastern New York and portions of New England; and over the central valleys and Great Lakes region from the 6th to 9th in connection with a shallow barometric depression over these regions. Also from the 10th to 12th there was more or less precipitation along the entire Atlantic coast, extending into the Alleghany Mountains and portions of the Ohio Valley and lower Lake region. At the same time there was rather wide spread precipitation in the far West, extending eastward into the Rocky Mountain districts and northern Great Plains on the 13th and 14th.

On the 18th there was considerable precipitation over a narrow belt from Arizona northeastward to the upper Lake region, and during the following two days the precipitation area extended into portions of the eastern districts, the falls becoming heavier and more general over the Atlantic Coast States.

A widespread area of precipitation, mostly light, however, with considerable snow, overspread the northern half of the country from the Plateau region to the middle Plains and upper Lakes on the 25th, the rain area extending southward and slightly eastward during the following two days, finally developing into a storm of some importance over the Lake region on the 28th. During the following 24 hours another storm that had developed over Wyoming on the 28th moved to Nebraska and thence to the Lake Superior district during the 29th and 30th, attended on the 29th at points in Iowa by sea-level pressures as low or even lower than ever before observed in September and by local storms, among the severest of which was the tornado at St. Louis, Mo. Also rains were the most general of the month on these days over a wide area from the northern and middle Plains eastward to the lower Lakes and Ohio Valley, the falls being particularly heavy in the middle Mississippi and lower Ohio Valleys.

The most important anticyclone of the month, measuring its effects on the general weather existing at the time, appeared first in the United States on the morning of the 18th over the northern Rocky Mountain districts; then moved southward and eastward into the central valleys, bringing important changes in temperature, and was further reinforced on the 20th, when temperature falls of 20° or more occurred over portions of the upper Missouri Valley, and the first general frosts of the season were reported at exposed points in Montana and Wyoming and thence eastward into western Minnesota and northern Iowa. The high-pressure area remained somewhat stationary over the Missouri Valley and near-by areas for several days during the early part of the third decade, attended by local frosts at scattered, exposed points in the upper Mississippi Valley and near-by areas. This anticyclone gradually drifted eastward with rising temperature, but was followed on the 25th by another that entered the upper Missouri Valley and near-by areas, with temperature falls of 20° or more in North Dakota and eastern Montana, followed by similar temperature changes during the following day to the southward as far as the Panhandle of Texas and western Oklahoma, but accompanied by general rains or snows which prevented severe freezing. Cloudy, rainy weather over the districts to the southward and eastward prevented any further important lowering of the temperature in near-by areas, and there was a general reaction to higher temperatures over most districts toward the end of the month.

The average pressure over both the United States and Canada, as far as observations disclose, was below the normal for September nearly everywhere, the depression being most pronounced in the middle and northern portions of the United States.

Comparison with the average pressure for the preceding month is shown on the inset to Chart II of this REVIEW.

Under the atmospheric pressure conditions existing, the prevailing winds were mainly from southerly points during much of the month from the Great Plains eastward, save that they were frequently from northeast to east over the South Atlantic and East Gulf States. West of the Rocky Mountains they were locally from the northwest over the Pacific coast districts, from southerly points in portions of the Plateau, and variable elsewhere.

Details regarding the severe storms of the month, which were comparatively infrequent save in portions of the upper Mississippi Valley and near-by areas on the 29th, appear in the tables at the end of this section.

TEMPERATURE

The temperature was marked by wide extremes over the different portions of the month and country, the first half being unusually warm over most districts from the Rocky Mountains eastward, while the latter part was distinctly cool in this region; also the far western portions had a period of decided coolness in the second decade.

By weeks the temperature conditions are outlined in the main by the following résumé:

About the beginning of the first week there was a marked rise in temperature over all central and most eastern districts, the daily values rising above normal for the first time in several weeks over this region, and the week was mainly warmer than normal, but to a slight degree only, over much of the far West, though the Plateau region was usually moderately cool. The second week continued warm over the districts from the Rocky Mountains eastward, the period being particularly warm in the great central valleys where the weekly means ranged from 5° to 18° above the normal and the latter part of the week had temperatures in many cases the highest of record so late in the month. West of the Rockies this week was distinctly cool, some portions of the Plateau having weekly means from 8° to 12° below normal.

The greater part of the third week continued unusually warm in the eastern two-thirds of the country, though toward the end cooler weather set in over the Rocky Mountain and near-by areas and gradually extended eastward so that by the close temperatures were mainly below normal over all districts from the Rocky Mountains eastward. This week continued moderately cool over the far West.

The fourth week was mainly cool from the Rocky Mountains eastward during the first half, but thereafter there was a reaction to warmer over the central valleys and southern portions, but by the 25th decidedly cool weather had again overspread the Missouri Valley and near-by districts, and during the following few days the lowest temperatures of the month were recorded at local points in the Plains States and southern Rocky Mountain region. The last few days of the month had in the main temperatures near normal in practically all portions of the country.

The average temperatures for the month as a whole were above normal from the eastern slope of the Rocky Mountains to the Atlantic coast, save locally in the northern portions of New York and New England where a few points had averages slightly below. They were above normal also over the whole of southern Canada and along the Pacific coast from central California northward. In the central valleys the averages were from 2° to 5° above normal, and over much of this area they were from 2° to 3° higher than for the preceding August.

From the Rocky Mountains westward to the Pacific, save as indicated above, the September averages were below normal, though not materially so save in the central Plateau region.

PRECIPITATION

Considering the country as a whole, the month was drier than normal, the lack of rain being quite pronounced over the Atlantic and Gulf States where the monthly

deficiencies ranged up to more than two inches, and locally the amounts were the least or nearly so of record for the month. On the other hand, precipitation was distinctly above normal in the Lake region and to westward of the Rocky Mountains, except for California and Nevada where the State averages were slightly less than normal. At Cairo, Ill., and Portland, Oreg., the monthly amounts were the greatest for September in the 55 years of record.

SNOWFALL

Such snow as fell was confined mainly to the middle and northern Rocky Mountain and near-by areas and occurred chiefly on the 25th and 26th. In Colorado the total falls ranged from traces at low elevations to as much as 25 inches on some of the high mountains. The amounts were less in Wyoming and the near-by areas of Montana and in the Black Hills of South Dakota. In western Nebraska the depths ranged up to 5 inches or more, and western Kansas had smaller amounts. In some of these areas the snowfall for the month was not only the first but the greatest ever observed in September. Slight falls were recorded locally at a few points in other western mountain districts and locally from North Dakota to the upper Lake region.

The highest temperatures of the month occurred mainly from about the 15th to 18th, though in portions of the Southwest they occurred on the 1st, and over much of the remaining territory to westward of the Rocky Mountains from the 3d to 6th.

In many districts from the Great Plains eastward the maximum temperatures during the first half of the second decade were the highest ever recorded so late in the month and in some cases the actual highest ever recorded in September, and the daily averages during portions of the period frequently covered the longest periods of continuously high temperatures ever known in the month.

Temperatures above 100° were recorded at some time during the warm period in practically all the States save from the Great Lakes and Ohio eastward and a few in the far Northwest, where they were slightly less.

The lowest temperatures of the month occurred mainly during the last decade and chiefly during the first half of it.

Frosts occurred generally in the northern Rocky Mountains and eastward over portions of the Plains States on the morning of the 20th, about the normal date for the first frosts in that region, but thereafter there was little additional frost, and at the end of the month freezing weather or killing frosts had not yet occurred over any important agricultural sections of the country.

RELATIVE HUMIDITY

In the areas of deficient rainfall in the Atlantic and Gulf States the percentages of relative humidity were less than normal and distinctly so from eastern Texas to the South Atlantic coast. Smaller deficiencies occurred in California and locally in the Lake region and Ohio Valley. Elsewhere the percentages were mainly above the normal, and they were unusually high in the Rocky Mountain districts and far Northwest.

SEVERE LOCAL STORMS, SEPTEMBER, 1927

The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.

Place	Date	Time	Width of path, yards ¹	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Benkelman, Nebr.	1	12:40 p. m.	2,640		\$2,000	Heavy hail	Gardens considerably damaged over path 3 miles long.	Official, U. S. Weather Bureau.
Dunn, Chippewa, Clark, and Marathon Counties, Wis.	2	Noon	1-3 mi.		30,000	Severe wind, hail, and probably small tornado.	Silos and farm buildings damaged; corn and tobacco crops badly injured. Probably small tornado near Milan.	Do.
Floyd County, Iowa	2	5 p. m.			7,325	Hail and wind	Electric lines, buildings, and crops damaged.	Do.
Worth County, Iowa	2					do	Heavy crop damage.	Do.
Cohmor, N. Mex.	3	1:20 p. m.	2,640			do	Much injury to alfalfa and bean crops.	Do.
Milan, Tenn.	3				100,000	Electrical	Barn burned by lightning; 18 horses killed; carload of wagons and much feedstuff destroyed.	Do.
Dallas, Tex., and vicinity	4	7:30 p. m.			35,000	Wind and rain	Larger building under construction wrecked; other buildings damaged; several persons injured.	Do.
Franklin, Tenn.	4		880			Wind	Many trees blown down; considerable crop damage over a 4-mile path.	Do.
Mobile, Ala.	4				4,150	Electrical	Several buildings damaged by lightning.	Do.
St. Louis County, Mo.	5		16		700	Straight winds	A number of large oaks uprooted; other minor damage. Storm covered two paths, each 50 feet wide, 600 feet long and about 150 feet apart.	Do.
Winston-Salem, N. C. (near)	8					Heavy hail	About 2,000 acres of corn and tobacco damaged.	Charlotte Observer (N. C.).
Peoria, Ill., and vicinity	8-9				75,000	Electrical and rain	A number of barns destroyed by lightning; one home wrecked; much damage by flooding.	Official, U. S. Weather Bureau. Daily Democrat (Davenport, Iowa).
Oswego and Wolf Point, Mont., and vicinity	10	P. m.			5,000	Thunderstorm and wind	Small buildings blown down; several granaries moved; crops injured.	Official, U. S. Weather Bureau.
Baldwinsville, N. Y.	10				15,000	Severe thunderstorm	Barns destroyed by lightning.	Do.
Syracuse, N. Y.	10				50,000	do	One home and a number of barns destroyed by lightning.	Do.
Mildred, Mont.	12	7:45-8 p. m.			5,950	Violent wind	Roofs, chimneys, windows, and lumber yard damaged; 1 man injured.	Do.
Middleville, Mich. (near)	12	10 p. m.	100		10,000	Tornado	Farm buildings and crops damaged.	Do.
Toledo, Ohio	13	A. m.			80,000	Thunderstorm, hail and wind	Communication lines torn down; trees uprooted; light service impaired; 2 oil tanks set fire.	Do.
Delaware and Schuylkill Counties, Pa.	15					Wind and rain	Trees and poles prostrated; several small buildings unroofed.	Do.
Kossuth County, Iowa	17	3 p. m.	2-4 mi.		50,000	Hail and wind	Considerable damage to crops and buildings; path 8 miles long.	Do.
Louis County, Iowa	17	8 p. m.				Wind	Considerable property damage reported.	Do.
Aurora and Batavia, Ill., and vicinity	17				17,500	Electrical and wind	Wire systems and trees damaged; several buildings struck by lightning.	Do.
Muscatine County, Iowa	17	P. m.				Wind	Telephone and telegraph wires and trees blown down; crops injured.	Do.
Vernon County, Wis.	17		880		10,000	Heavy hail	Damage chiefly to tobacco.	Do.
Carrollton, Ga.	18		1		12,500	Thunderstorm	Cotton ignited by lightning and destroyed.	Do.
Harrisburg, Pa.	18				30,000	Wind and rain	Poles, trees, and small buildings damaged; traffic delayed; many cellars flooded.	Do.
Memphis, Tenn.	18				150,000	Electrical	Warehouse burned; telephone and lighting systems damaged.	Do.
Frijoles Canyon N. Mex.	22	4-4:30 p. m.	440		2,500	Heavy hail	Gardens and fruit damaged.	Do.
Demonstration Farm, N. Mex.	22-23					do	Corn, peas, and truck gardens considerably injured.	Do.
Checotah, Okla. (near)	29	A. m.				Small tornado	Two farm houses wrecked; 8 persons injured.	The Times (Oklahoma City, Okla.).
Rudy, Ark.	29	9:29 a. m.	100		75,000	Tornado	13 buildings wrecked; heavy damage to fruit and forest trees; 16 persons injured.	Official, U. S. Weather Bureau.
Audubon County, Iowa	29	Noon	440		4,000	do	Crops, buildings, and trees damaged; path 6 miles long.	Do.
French, Ark., to Poplar Bluff, Mo. (near)	29	1 p. m.	130-880	2	15,000	do	A number of buildings wrecked or partially wrecked; 14 persons injured.	Do.
St. Louis, Mo. (southwest part) to Granite City, Ill. (southeast of)	29	1 p. m.	100-1,700	79	30,000,000	do	About one-sixteenth of the area of St. Louis laid waste; much damage to industrial plants in Illinois; about 550 persons injured.	Do.
Menlo, Iowa	29	1:30 p. m.			5,000	do	Buildings, trees, and wires blown down; path 2 miles long.	Do.
Cowden, Ill. (near)	29	3 p. m.	200	1	10,000	do	Considerable property damage over path 12 miles long; 3 persons injured.	Do.
Ripley County, Mo.	29	3 p. m.	440		1,300	do	Several houses unroofed; windows broken; crops damaged over an irregular path about 10 miles long.	Do.
Edgar and Vermilion Counties, Ill., to Cates, Ind.	29	5 p. m.	100-880		80,000	do	Farm buildings damaged or destroyed; stock killed; crops hurt; 3 persons injured.	Do.
Scott Field, Ill.	29	6:33 p. m.	60		30,000	Wind	Army property damaged; path 2 miles.	Do.
Conlogue and Paris, Ill., and vicinity	29	8:30 p. m.			30,000	Tornadoic wind and electrical	Several buildings demolished; barns burned; crops injured.	Do.
Lurton, Ark. (near)	29	10 and 10:30 p. m.				2 tornadoes	Timber destroyed also a home and school building wrecked.	Do.
Allamore County, Iowa	29	P. m.				Tornado	Buildings and trees damaged.	Do.
Brookfield, Mo. (near)	29	P. m.			400	do	One barn demolished; path short.	Do.
Wabash and Spencer Counties, Ind.	29					High wind	Telephone property and crops damaged.	Do.

¹ Mi. signifies miles instead of yards.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

The month was very quiet in the Washington district. Few disturbances of importance reached the Atlantic coast, and the only tropical disturbance that required advisory warnings was the one that was central southwest of Bermuda and moving northwestward on the morning of the 11th. During the day it recurved to the north and later toward the northeast, passing to the north of Bermuda early on the night of the 11th. No storm warnings were required during the month, but small-craft warnings were issued for the Rhode Island and Massachusetts coasts at 10:30 a. m. of the 1st, in connection with a disturbance of only moderate intensity that developed south of Cape Hatteras and passed inland over Connecticut shortly after 8 p. m. of the 1st. No frost occurred in the Washington district until the morning of the 21st, when stations in Kentucky, western Ohio, and northwestern Tennessee reported light frost. The only heavy frost reported during the month was at Northfield, Vt., on the 22d. Warnings of light frost were issued on the 21st and 22d for eastern West Virginia, the extreme western portions of Maryland, Virginia, and North Carolina, and the cranberry bogs of New Jersey, and on the 23d for northern Vermont.—*O. L. Mitchell.*

CHICAGO FORECAST DISTRICT

The mean temperature for the month was above the seasonal normal for practically the entire forecast district, the only exception being the extreme western portion of the Great Plains. The month, moreover, was exceedingly warm up to about the 17th, and relatively cool weather prevailed for about six days following. The first half of the month showed record-breaking means at several stations. Indeed, at some stations abnormally high maxima were reported, 95° being quite common; 99° at Des Moines, Iowa, was the high mark at any regular Weather Bureau station, and readings in excess of 100° were recorded at some cooperative stations. Thus the temperature conditions were quite abnormal, but they had a decidedly favorable effect in bringing crops, such as corn, to maturity. During this protracted warm period the weather was mostly fair, with very little rainfall in the district; but considerable rainfall occurred during the last two weeks, the amounts in some places in the eastern portion of the district bringing the totals up to more than twice the monthly averages.

The movement of high and low pressure areas was decidedly sluggish, especially during the dry and warm period; and the lows which appeared in the West were largely dissipated before they reached the Mississippi Valley. However, weather conditions were much more active during the closing week of the month.

Frosts worthy of note were first brought in by an area of high pressure which appeared in British Columbia on the 17th. On the 19th, 20th, 21st, and 22d frosts were noted over the northern and central Great Plains and on the last two dates they extended southeastward over the Ohio Valley; and there were also frosts in the

district from Lake Michigan westward across the Dakotas on the 23d. Warnings for these frosts were issued for practically the entire areas affected, although in some instances these areas were not exactly coincident with the limits set by the warnings.

The weather conditions, as stated above, were more or less unsettled during the third decade, "weatherbreeders," so to speak, the barometer being low over a wide area, especially in the closing days of the month. A disturbance, which afterward became of marked importance, appeared in the Northwest on the 27th. This took a southeastward direction with a more or less irregular development, and on the morning of the 28th it was centered in the middle Missouri Valley. The lowest barometer was then 29.34 inches at Concordia, Kans., and thunderstorms and rain prevailed throughout most central districts. By 2 p. m. the storm had moved northeastward to northwestern Iowa, the lowest barometer reading being 29.24 inches at Sioux City and Des Moines, Iowa. It was just at this time that a tornado of considerable importance occurred at St. Louis, which was located in the southeast quadrant of the storm area. Showers and thunderstorms were forecast for the area affected by this storm, and storm warnings were displayed before and during the passing of the storm on the Great Lakes, where strong winds and squalls almost generally prevailed.

Special services in the way of frost warnings were continued to the cranberry marshes of Wisconsin, and fire-weather warnings were sent to the station at Duluth for distribution to the forests of Minnesota from September 15 to 24, inclusive.

Special service by this office was given in the interest of the international balloon race which started at Detroit on the afternoon of September 10. This service was confined to extended forecasts of Zone Four for wind and weather conditions at surface and aloft, in greater detail than is customary in the bi-daily forecasts, which were wired to several points for special broadcast at Detroit, Albany, New York, and Cincinnati on the 10th and 11th, and the one on the 10th for special use at the starting point at Detroit.

Special flying-forecasts were made for the flying routes over this forecast district during the national air derby from New York to Spokane, starting in New York on the 19th. The flyers were met upon their arrival at the municipal airport in Chicago by the forecasters, and the special forecasts were given to the pilots before their departure westward. Additional forecasts were wired to St. Paul en route.—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT

Summer types of pressure distribution, with persistently warm weather and periods of local showers, continued until the 18th-20th, when high pressure from the Northwest advanced to the west Gulf coast, attended by cooler weather, which prevailed for about a week and was followed by warm weather during the last few days of the month.

See p. 405 of this REVIEW. The Alaska Forecast District, which covers the North Pacific coast and southeast coast of Alaska, was organized at points north of Cape Blanco. Southern gales prevailed along the coast the following month. Warnings of local frosts were issued on the 14th and 15th for parts of the plateau and interior regions.—*Thomas A. Reed.*

Warnings were issued on the 20th for frost in the extreme northern portion of the district, on the 26th for probably freezing weather in northwestern Oklahoma and the Texas Panhandle, and on the 27th for frost in northern Oklahoma "if weather clears." Conditions were approximately as forecast in the first two instances, but cloudy weather prevented frost on the morning of the 28th.

No storm warnings were issued or required. Small-craft warnings were displayed in the Corpus Christi, Tex., district on the 19th and on the east coast of Texas on the 29th and were justified.—*R. A. Dyke.*

DENVER FORECAST DISTRICT

Lows of marked intensity moved eastward along the northwestern border with unusual frequency, while troughs of pressure extended southward or southwestward across the Rocky Mountain region during much of the month. A number of disturbances also advanced eastward from the Plateau States. Highs of important development passed across the northern Rocky Mountain sections from the 17th to the 20th and on the 24th and 25th.

These pressure conditions were attended by precipitation much in excess of normal in the central and northeastern portions of the district and by a deficiency in portions of central and western Montana and along the southwestern border. It was colder than the seasonal average from Montana southward to Utah and northern New Mexico. On the 25th and 26th snow extended southward along the eastern slope of the Rockies to northeastern Colorado.

Brisk to strong westerly winds were forecast on the morning of the 1st for Wyoming and Montana, strong westerly winds on the evenings of the 13th and 27th for Wyoming and eastern Colorado, and brisk to strong westerly winds on the morning of the 28th for eastern Colorado and strong westerly winds for Wyoming and that portion of Montana east of the Divide. The forecasts were generally verified.

Frost or freezing temperature warnings were issued for those portions of the district where they were required on the 7th, 10th, 13th, 14th, 15th, 17th, 18th, 19th, 20th, 21st, 24th, 25th, 26th, 27th, 29th, and 30th. These also were generally verified.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT

A disturbance of the Cordova type required small-craft warnings to be displayed at Washington seaports on the 2nd, which were changed to southwest-storm warnings at coast stations later in the day. Winds along the coast reached gale force the following night. On the 4th southeast-storm warnings were displayed at Oregon and Washington seaports, which were followed by gales on the coast during the ensuing 24 hours. On the 11th a disturbance which originated in the Gulf of Alaska called for small-craft warnings at Washington stations. After this no further warnings were required until the 26th, when a very large low-pressure system of winter type, central near the Alaskan Peninsula, encroached upon the North Pacific coast, and southeast-storm warnings were displayed at points north of Cape Blanco. Southerly gales prevailed along the coast the following night.

Warnings of local frosts were issued on the 14th and 15th for parts of the plateau and intermountain regions.—*Thomas R. Reed.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD

There were no floods of consequence during the month of September. Heavy rains on September 5 and 6 over the drainage basins of the Little Arkansas River and Chisholm Creek necessitated flood warnings on the 6th for those rivers. No material damage was done along the Little Arkansas River, but waters from Chisholm Creek inundated about 40 acres of land in North Wichita, Kans., some of which was residential, and some stockyards property. The damage amounted to several thousand dollars.

On September 6 a warning was issued for the Solomon River at Beloit, Kans., and two days later a crest of 22.5 feet occurred, 4.5 feet above the flood stage.

Persistent low pressure over the plateau region and Arizona caused a period of showery weather with occasional local downpours of rain from September 6 to 14. On the 10th and 11th the San Juan River at Farmington, N. Mex., rose above the flood stage of 8 feet, reaching a crest of 9.6 feet on the 11th. There was also a decided rise in the Colorado River, for which warnings were necessary, although flood stages were not reached except at Parker, Ariz., where the flood stage of 7 feet was exceeded by 3.8 feet on September 18, the river remaining above the flood stage from September 14 to 25, inclusive.

Although no serious damage was done, the heavy local rains caused numerous washouts and earth slides along the highways and railroads in southwestern Colorado and northwestern New Mexico.

Following heavy local rains in Arizona on September 12 and 13, flash rises occurred in a number of streams, but without damage. Warnings were issued on September 12.

River and station	Flood	Above flood stages—dates		Crest	
		From	To	Stage	Date
Wabash-Tipppecanoe River: Norway, Ind.	Feet	30	(?)	6.0	30
Solomon River: Beloit, Kans.	18	7	8	22.5	8
Rio Grande: San Marcial, N. Mex.	2	14	14	4.0	14
Colorado River: Parker, Ariz.	7	14	25	10.8	18
Colorado-San Juan River: Farmington, N. Mex.	8	10	11	9.6	11
Gila River, Kelvin, Ariz.	5	12	12	6.0	12
Salt River, Phoenix, Ariz.	5	12	12	8.5	12

¹Probably continued at end of month.

MEAN LAKE LEVELS DURING SEPTEMBER, 1927

By UNITED STATES LAKE SURVEY

(Detroit, Mich., October 5, 1927)

The following data are reported in the "Notice to Mariners" of the above date:

Date	Lakes ¹			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during September, 1927:	Feet	Feet	Feet	Feet
Above mean sea level at New York:	602.70	579.16	571.68	245.27
Above or below:				
Mean stage of August, 1927:	-0.07	-0.30	-0.33	-0.50
Mean stage of September, 1926:	+1.37	+0.65	+0.25	+0.41
Average stage for September last 10 years:	+0.46	-0.96	-0.44	-0.43
Highest recorded September stage:	-1.38	-4.27	-2.26	-2.34
Lowest recorded September stage:	+1.37	+0.94	+0.75	+1.27
Average departure (since 1860) of the September level from the August level:	+0.05	-0.20	-0.25	-0.40

¹Lake St. Clair's level: In September, 1927, 574.36 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, SEPTEMBER, 1927

By J. B. KINCE

General summary.—Generally warm, dry, and sunshiny weather prevailed in nearly all sections east of the Rocky Mountains during the first three weeks of the month, making conditions unusually favorable for maturing late crops and enabling farm work to make rapid advance. It was especially favorable in forcing the late corn crop to maturity and all growing crops were greatly benefited. Showers were helpful in some north-central and south-western districts, but many areas were still in need of moisture, especially in southwestern Nebraska and western Kansas. Rain was needed also in the South for late crops, but the drought was relieved in the Pacific Northwest and beneficial precipitation occurred in the far Southwest.

There was a continuation of warm weather until near the close of the second decade, when an abrupt change to cooler halted progress of late fall crops. Rains in the west Gulf area were beneficial and showers were helpful in areas from the upper Mississippi Valley eastward, but there was a rather widespread need of moisture in many places. At the close of the month the cool waves brought killing frosts over much of the Northwest, at about the average first frost date, and lighter frosts to scattered localities, principally on lowlands of the interior valley States. In the interior the frost was not severe enough to do more than local damage to tender vegetation, while in the Northwest most of the staple crops had matured. Rains from the Lake region southwestward were beneficial in conditioning the soil for plowing and fall seeding and for pastures and unmaturing crops, but from the Ohio Valley and Middle Atlantic States southward moisture was quite generally needed and very little was received during the latter part of the month. There was also need of more rain in parts of the Southwest, but in the Pacific Northwest showers and warmth made a favorable period.

Small grains.—During the first part of the month conditions were generally favorable in the Northwestern States, particularly in the Spring Wheat Belt, and harvesting and threshing made good progress. Harvest was practically completed in North Dakota and threshing was well along; there was some slight interruption to this work in northern Rocky Mountain sections, but in general good advance was made. Rain was needed in interior sections for fall plowing, especially in the Ohio Valley States, but much wheat ground had been prepared. In the trans-Mississippi area the soil was mostly in good condition, but in the Lake region rain was needed to soften it. Rains during the second decade caused some delay to threshing and harvesting, principally in western Montana, Idaho, and the eastern portions of Washington and Oregon. East of the Rocky Mountains threshing made good progress and preparations for fall seeding advanced with the soil in good condition in most sections, though additional moisture would have been helpful in parts. Threshing made good progress in the spring wheat region during the last decade and the seeding of winter wheat advanced very well, though in the western portion of the belt there was interruption by rain the latter part of the period. There was also considerable seeding in the northern portions of the eastern wheat belt, but moisture was needed for this work in most sections east of the Mississippi River.

Corn.—With the summer warmth and abundant sunshine during the first decade in most sections of the

Corn Belt forcing maturity at an unusually rapid rate, the progress of the corn crop was generally good to excellent in practically all portions east of the Rocky Mountains. Progress in Iowa was fair to excellent, except on some uplands where it was too dry. In other trans-Mississippi States conditions were very favorable; corn was nearly all matured in Oklahoma and much was sufficiently advanced for seed in South Dakota.

Under continued favorable conditions during the second decade the bulk of the crop was safe from frost in Kansas by the close of the period and probably three-fourths was safe in Nebraska and South Dakota. Much corn in Iowa needed a continuation of favorable conditions for maturity, but most of it was safe in Missouri, and the crop was made farther south. The cool wave the beginning of the last decade caused corn to make slow progress toward maturity, but there was no widespread damage from this cause. Harm was somewhat greater in Central-Northern States outside the main Corn Belt, principally in Wisconsin and Minnesota. Except in Iowa, the bulk of corn was safe from frost at the close of the month in most main producing trans-Mississippi areas. East of the Mississippi River the crop was in much less favorable condition as to maturity, especially in Illinois and Indiana, where a large amount was still green.

Cotton.—During the first decade better weather prevailed in the Cotton Belt, with higher temperatures in the northern and more eastern States and showers in parts of Texas. The crop showed some improvement in the Carolinas and Virginia, and in Georgia progress was mostly good, but condition continued to vary greatly, with weevil still active and no top crop indicated in the southern portions. In Alabama progress ranged from deterioration in some sections to fair in others; rains were unfavorable in Louisiana, but in Arkansas progress was fairly good in most portions. In Oklahoma advance ranged from very poor to poor in the south-central and eastern portions, where weevil continued active and destructive, but good to very good in the west. In Texas rains reduced premature opening, and progress continued good in the northwest and parts of the west; deterioration in the northeast was checked by showers, but elsewhere it continued and prospect for a top crop was poor.

During the second decade a continuation of warm, dry weather was favorable from the aspect of weevil, but considerable shedding of young bolls was reported from some drier sections of the east. Because of the dryness and warmth, shedding was reported from the Piedmont section of the Carolinas. Early bolls were about all open in Tennessee, while in Alabama and Mississippi rapid opening was noted. Late cotton on previously overflowed land in Louisiana was rather uncertain, but in Arkansas good advance was reported. Weevil were still active in Oklahoma, and there was no general change in the situation in Texas.

During the last decade conditions remained practically unchanged in the eastern belt, with bolls opening rapidly and picking and ginning progressing well. In Louisiana weevil and worms continued to take the top crop, but in Arkansas progress was mostly very good. In Texas cotton opened rapidly, with picking and ginning progressing well, but general progress of the crop was poor. In Oklahoma the cool, wet weather was unfavorable and cotton deteriorated, or made only poor advance, with continued weevil and worm activity.

Ranges, pastures, and livestock.—Pastures needed rain during the first decade in the eastern Ohio Valley, much of the Lake region, sections of the South, and

locally in the Great Basin. Pastures and meadows were greatly benefited by rains in the Lake region during the second decade, but moisture in the South was generally insufficient and the continued dry weather was detrimental. Beneficial showers occurred in portions of the Great Basin and Arizona, and the prolonged wet spell was broken in the Pacific Northwest. Livestock continued in mostly good to excellent condition throughout the month.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

With the exception of the rather unusual disturbance of a tropical origin in the last decade of the month which will be referred to later, the weather conditions over the ocean during the month of September presented few abnormal characteristics. East of the 45th meridian gales were not reported on more than two days in any 5-degree square, while between the 35th and 45th parallels and the 45th and 60th meridians they occurred on from one to four days.

The number of days with fog was apparently somewhat below the normal over the Grand Banks, about normal off the American and European coasts, and considerably above over the middle section of the steamer lanes.

TABLE 1.—Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (75th meridian), North Atlantic Ocean, September, 1927.

Stations	Average pressure	Departure ¹	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Belle Isle, Newfoundland.....	29.75	-0.15	30.30	1st.....	29.18	17th.
Halifax.....	29.98	-0.03	30.42	28th.....	29.40	12th.
Nantucket.....	30.02	-0.02	30.40	28th.....	29.60	11th.
Hatteras.....	30.03	0.00	30.26	25th.....	29.72	11th.
Key West.....	29.93	-0.04	30.04	5th.....	29.86	11th.
New Orleans.....	29.99	0.00	30.16	2d.....	29.84	18th.
Cape Gracias-a-Dios, Honduras.....	29.83	-0.05	29.88	5th.....	29.78	29th.
Turks Island.....	29.97	0.00	30.04	3d.....	29.88	29th.
Bermuda.....	30.02	-0.03	30.24	30th.....	29.76	12th.
Horta, Azores.....	30.22	+0.06	30.42	28th.....	29.70	21st.
Lerwick, Shetland Islands.....	29.63	-0.21	30.26	8d.....	28.92	24th.
Valencia, Ireland.....	29.94	-0.15	30.23	12th.....	29.30	24th.
London.....	29.92	-0.08	30.24	2d.....	29.15	24th.

¹ From normals shown on H. O. Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m., 75th meridian.

² Cape Gracias-a-Dios, on the extreme eastern coast of Honduras, was substituted for Swan Island, the latter station having been discontinued on Sept. 1, 1927.

³ And on other dates.

During the first two days of the month moderate conditions prevailed generally, although on the 2d a depression was over the eastern section of the steamer lanes that afterwards developed into a fairly well defined disturbance which on the 3d was central near 55° N., 30° W., with moderate to whole gales in the southerly quadrants.

On the 5th Belle Isle was near the center of a Low that afterwards developed into a severe disturbance, although of limited extent and short duration. On the 6th this depression had moved but little and deepened slightly, but on that day it was attended by moderate winds only.

On the 7th a comparatively well developed Low was over the middle section of the steamer lanes, with moderate southwest gales between the 40th and 45th parallels and the 35th and 40th meridians.

Miscellaneous crops.—At the close of the month potato digging was progressing in most portions, but warmer weather was needed in the Lake region. Truck needed moisture rather badly in the Southeast at the close; frost caused some slight injury to truck in Wisconsin. Sugar cane continued to make good progress, and sugar beets were being dug in parts of the west, with good sugar content reported. Apple picking had started in the Pacific Northwest at the close.

A report was received from the British S. S. *Matador* indicating that on the evening of the 7th and the morning of the 8th a severe local disturbance of short duration occurred in southern waters. The *Matador* received a radiogram from the British S. S. *Socrates* stating that on the morning of the 8th, in 21° 40' N., 51° 00' W., the barometer read 29.73, falling, wind SE., force 10. Storm center moving toward NW.

On the 9th Belle Isle was again near the center of a disturbance that moved but little during the next 24 hours, decreasing in intensity.

On the 12th the Maritime Provinces were covered by a depression, while a secondary Low was central a short distance east of the Bermudas, and vessels between the two centers encountered winds of from force 4 to 9.

From the 13th to 19th the weather over the ocean was, as a rule, favorable, although during this period reports were received from a few vessels that had encountered gales, and on the 15th northerly winds of force 7 were reported by land stations in southern England.

On the 20th and 21st a severe but limited disturbance was in the vicinity of the Azores, and on the latter date westerly winds of force 10 prevailed in the southerly quadrants.

On the 23d a "double Low" was in European waters; the southern center was near Portland Bill and the northern near Lerwick, and winds of hurricane force were reported by vessels in the English Channel. By the 24th these two Lows had evidently combined, the center now being over the North Sea, while northerly gales still prevailed off the coast of northern Europe and between the 45th and 55th parallels and the 20th and 30th meridians.

The existence of the tropical disturbance of this period, which has already been referred to, was first definitely established on the 24th. The center on that date was in approximately latitude 25° N., longitude 54° W., with a direction of movement almost due northwestward. This movement, had it been maintained, would have carried the center close to Bermuda. However, the storm began to recurve on the 25th and the westernmost point of its path was the 61st meridian, reached about midday of the 26th. Completing the recurve by the morning of the 27th, the storm moved in a northeasterly direction, and on the morning of the 30th the center appeared to be at latitude 45° N., longitude 49° W. Its subsequent history has not yet been determined.

The general period of these two disturbances, extending from the 24th to the 29th, is covered by Charts VIII to XIII, which give an idea of their extent and intensity from day to day.

NOTE.—American S. S. *Bogota*, Capt. H. U. Davis, from Kingston to New York:

On September 15, in 25° 25' N., 74° 34' W., observed two large and one small waterspouts within one-half to 3 miles of the ship, followed by thunder and heavy rain showers. No change in barometer. Wind veered from NE. all the way round the compass one-half hour from 4.30 to 5 p. m.

ADDITIONAL NOTE ON AUGUST HURRICANE
 The British S. S. *Highland Prince*, Capt. John Davis, Observer Samuel A. Wheaton, from New York to Rio de Janeiro, rendered a report that was received too late to include in the article for the August REVIEW. At Greenwich mean noon on August 20 the vessel was in 21° 55' N., 53° 05' W., and reported wind NE., 7, barometer 30.03 inches. The storm report states that the gale

began on the 20th, wind NE., lowest barometer 29.93 inches, wind ENE., 9, at 4 p. m. on the 20th, in 21° 15' N., 52° 30' W. End of gale on the 21st, wind E. Highest force of wind E., 12. Shifts, NE.-E.-ENE.-E. On the 20th the *Highland Prince* was evidently some distance north of the center of the disturbance. Unfortunately, it is impossible to plot the position of the center due to lack of observations, as this was the only report received from that region.

OCEAN GALES AND STORMS, SEPTEMBER, 1927

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN													
Bolivier, Belg. S. S.	Antwerp	New York	50 37 N.	27 44 W.	Sept. 1	11 p.	1	29.62	SW	WSW, 8	NW	W, 9	W-NW.
Minnesota, Br. S. S.	New York	Boulogne	41 11 N.	54 12 W.	5	1 p.	5	29.47	SW	SW, 11	NW	W, 13	SW-W-NW.
Elzasier, Belg. S. S.	do.	Antwerp	46 35 N.	35 45 W.	7	2 p.	7	29.47	NE	NE, 8	NNW	NE, 9	NE-N.
Mercier, Belg. S. S.	Antwerp	New York	50 29 N.	26 07 W.	7	Mdt.	7	29.51	SW	SW, 8	NW	NW, 10	
Rochambeau, Fr. S. S.	Havre	do.	42 45 N.	50 39 W.	9	7 a.	9	29.57	W	W, 8	NW	W, 8	
Illingworth, Br. S. S.	River Tyne	Galveston	31 20 N.	51 10 W.	10	8 p.	10	29.82	S	S, 7	SW	S, 8	S-SW.
Tynfield, Br. M. S.	London	do.	35 05 N.	59 56 W.	11	1 a.	12	29.70	Var	S, 7	W	Var, 8	S-SW-W.
Providence, Fr. S. S.	Boston	Lisbon	40 45 N.	53 30 W.	11	8 p.	12	29.49	S	SSE, 7	WSW	SSE, 9	SSE-S-WSW.
Arkansas, Dan. S. S.	Baltimore	Rotterdam	40 15 N.	9 44 W.	14	4 p.	14	29.50	WSW	NNW, 9	N	NNW, 9	W-NW-N-NNE.
Dresden, Ger. S. S.	Bremerhaven	New York	45 23 N.	46 44 W.	16	9 p.	16	29.33	SW	SW, 8	NNW	SW, 9	SW-W.
Marino O, Ital. S. S.	Naples	Beaumont	36 00 N.	28 40 W.	20	10 p.	20	28.95	SW	NW, 10	NW	—	
Tulsa, Am. S. S.	Rotterdam	Savannah	42 10 N.	8 50 E.	22	1 p.	22	28.82	S	S, 8	NW	SW, 12	
New York City, Br. S. S.	Cardiff	Philadelphia	50 30 N.	21 27 W.	23	Mdt.	23	29.28	NW	NW, 9	NNW	N, 9	NW-N.
St. Anthony, Am. S. S.	Santos	Boston	27 32 N.	55 49 W.	24	—	24	29.46	NE	ESE, 10	N	NE, 11	NE-ESE.
Sagaporaek, Am. S. S.	New York	Copenhagen	59 21 N.	7 53 W.	24	4 p.	24	29.22	NNE	NNE, 9	NNE	NNE, 9	Steady.
Compass Peak, Am. S. S.	Rotterdam	Seville	31 32 N.	60 16 W.	26	4 a.	26	28.67	SE	SE, 8	NW	E, 12	
Middrecht, Du. S. S.	Seville	New Orleans	31 08 N.	61 00 W.	26	7 a.	26	29.06	NE	N, 12	NW	N, 12	NE-N-NW.
Antinous, Am. S. S.	Mobile	London	39 43 N.	59 47 W.	27	Noon	27	29.40	ENE	ENE, 11	NNW	ENE, 11	ENE-N-NNW.
Speardam, Du. S. S.	Antwerp	Habana	37 37 N.	60 43 W.	27	10 a.	27	29.35	ENE	N, 10	NNW	N, 10	ENE-N-NNW.
Giuseppe Verdi, Ital. S. S.	Lisbon	New York	37 50 N.	59 03 W.	27	11 p.	27	29.02	S	WNW, 12	NW	NW, 12	S-SW-W.
Asuncion de Larrinaga, Br. S. S.	Manchester	Galveston	55 00 N.	18 30 W.	27	10 p.	27	29.33	SW	WSW, 8	WSW	WSW, 9	WSW-W.
Bolivian, Br. S. S.	London	New York	42 44 N.	52 48 W.	28	6 p.	28	28.98	NE	NE, 7	NNW	NNW, 12	SSE-NE-NNW.
Narragansett, Br. M. S.	Hull	Baton Rouge	34 56 N.	46 00 W.	29	7 a.	29	29.53	SSE	S, 11	SW	S, 11	
Pres. Harding, Am. S. S.	Cherbourg	New York	48 05 N.	52 15 W.	27	4 p.	29	29.18	SE	NE, —	N	—	SE-E-N.
Dresden, Ger. S. S.	New York	Bremerhaven	41 31 N.	64 46 W.	28	4 p.	29	29.73	NNE	NNW, 11	NW	NNW, 11	NNE-NNW.
Gov. John Lind, Am. S. S.	San Juan	Baltimore	25 39 N.	69 48 W.	30	2 p.	30	29.78	E	ENE, 8	E	E, 8	
De Grasse, Fr. S. S.	Havre	New York	47 45 N.	34 35 W.	30	11 a.	30	29.09	SSE	WSW, 11	NW	SSE, 12	WSW-NW.
United States, Dan. S. S.	New York	Christiansand	58 84 N.	8 33 W.	26	1 p.	30	29.39	SW	WSW, 7	SW	WNW, 10	
NORTH PACIFIC OCEAN													
West Sequana, Am. S. S.	San Francisco	Shanghai	34 44 N.	173 10 E.	3	10 a.	3	29.01	SE	SSE, 5	W	SE, 8	
Antietam, Am. S. S.	San Pedro	Tsushima	44 50 N.	140 15 W.	3	8 p.	3	29.80	W	W, 7	NW	WNW, 9	W-NW.
Proa Cleveland, Am. S. S.	Seattle	Yokohama	51 00 N.	177 30 W.	3	1 a.	6	29.05	WNW	W, 8	NNW	—	SE-SW.
Steel Voyager, Am. S. S.	Puget Sound	Panama	35 06 N.	121 08 W.	6	Mdt.	6	29.77	NNW	NNW, 6	NNW	NNW, 9	Steady.
Pawlet, Am. S. S.	Hakodate	San Francisco	49 38 N.	159 40 W.	4	—	5	29.06	S	S, 8	S	S, 8	Do.
Antietam, Am. S. S.	San Pedro	Tsushima	48 23 N.	153 00 W.	6	1 p.	7	29.57	SSW	SSW, 9	SSW	SSW, 9	Do.
Do.	do.	do.	50 20 N.	171 40 W.	10	8 p.	10	29.18	SSE	E, 9	E	E, 9	Do.
Akagisan Maru, Jap. S. S.	Longview	Yokohama	54 25 N.	169 40 W.	6	—	11	29.43	WSW	ENE, 7	E	S, 9	Variable.
Tabchee, Br. S. S.	Shanghai	San Pedro	49 00 N.	173 00 W.	10	—	10	—	ENE	ENE, 8	S	ENE, 8	ENE-E-S.
Tamaha, Br. S. S.	San Pedro	Hong Kong	25 00 N.	130 00 E.	11	2 a.	11	29.73	S	SW, 8	SW	SW, 8	S-SW.
Yoneyama Maru, Jap. S. S.	Malaka	Coos Bay	34 06 N.	124 35 E.	12	6 a.	14	29.30	SE	SW, 11	WSW	SW, 11	S-SW.
Stanley Dollar, Am. S. S.	Shanghai	San Francisco	47 00 N.	163 09 W.	15	4 p.	16	29.94	NNE	ENE, 5	SSE	NNE, 9	6 pts. to SE.
Nagato Maru, Jap. S. S.	Kamchatka	do.	49 00 N.	164 13 W.	15	Noon	16	29.37	NE	N, 9	S	NNE, 9	
Antietam, Am. S. S.	San Pedro	Tsushima	46 28 N.	163 23 E.	15	6 a.	16	29.71	SE	SE, 8	S	ESE, 9	
Atlantic Maru, Jap. S. S.	Yokohama	San Francisco	47 20 N.	169 16 W.	16	4 a.	17	29.38	SE	NNW, 8	S	NNW, 8	N-NNW.
Tatsuno Maru, Jap. S. S.	do.	do.	43 00 N.	153 20 W.	17	8 a.	17	29.84	SSE	SSE, 3	NE	SSE, 8	S-SE.
Tamaha, Br. S. S.	Hong Kong	San Pedro	22 30 N.	115 15 E.	19	10 p.	19	29.06	NE	NE, 7	NE	NE, 8	Steady.
West Cadron, Am. S. S.	Yokohama	Portland	37 50 N.	145 37 E.	23	2 p.	23	29.62	ENE	NNE, 8	N	N, 9	NE-N.
Tamaha, Br. S. S.	Hong Kong	San Pedro	30 06 N.	131 32 E.	25	9 a.	25	29.62	ESE	NE, 7	NE	NE, 12	NE-E.
Tahiti, Br. S. S.	Sydney	San Francisco	37 16 N.	123 00 W.	29	4 a.	30	29.88	NNW	NNW, 6	NNW	NNW, 8	Steady.
Manukal, Am. S. S.	Maul	do.	36 08 N.	126 38 W.	30	11 a.	30	30.21	N	N, 7	NNW	NNW, 9	N-NNW.
STORM REPORTS FROM WEST COAST OF MEXICO													
General Smuts, Br. S. S.	San Pedro	Callao	16 58 N.	106 45 W.	7	1 a.	8	29.76	SW	WSW, 10	WSW	WSW, 10	SW-WSW.
Dinteldijk, Du. S. S.	Los Angeles	Balboa	19 13 N.	105 32 W.	8	3 p.	8	29.50	ESE	ESE, 8	SSW	ESE, 8	ESE-SW.
D. G. Scofield, Am. S. S.	San Pedro	Baltimore	21 22 N.	108 37 W.	8	—	8	29.15	NW	SSE, —	SW	S, 12	E-S.
La Placencia, Am. S. S.	Balboa	San Pedro	21 06 N.	108 00 W.	8	4 a.	8	29.36	E	ESE, 8	S	ESE, 8	
W. S. Miller, Am. S. S.	San Francisco	Balboa	21 00 N.	108 00 W.	8	10 a.	9	29.40	E	E, 11	SSW	E, 11	E-S.
Axel Johnson, Swed. M. S.	San Pedro	do.	21 06 N.	108 20 W.	9	8 p.	9	29.05	ENE	S, 12	SW	S, 12	
Inverarder, Br. S. S.	Buenos Aires	San Pedro	14 50 N.	108 00 W.	7	2 p.	8	29.29	SW	SW, 9	SW	SW, 9	Steady.
Steel Voyager, Am. S. S.	Puget Sound	Panama Canal	24 25 N.	112 35 W.	10	4 a.	11	29.43	N	NE, —	WSW	N, 9	N-NW.
Minnesotan, Am. S. S.	Panama Canal	Los Angeles	17 00 N.	101 23 W.	10	2 a.	12	29.76	W	W, 10	W	W, 10	W-NW.
Salina, Am. S. S.	San Pedro	Panama Canal	22 53 N.	111 03 W.	10	5 a.	10	29.31	NNE	NW, 10	S	NW, 10	
Point Lobos, Am. S. S.	Balboa	San Diego	18 17 N.	103 32 W.	11	4 p.	12	29.45	SW	SW, 10	NNW	NNW, 8	W-NW.
W. S. Rheem, Am. S. S.	do.	San Pedro	16 01 N.	99 24 W.	12	4 p.	12	29.45	SW	SW, 10	NW	W, 11	SW-NW.
Meton, Am. S. S.	San Pedro	Norfolk	15 53 N.	99 37 W.	26	6 p.	26	29.70	E	E, 7	SSE	E, 8	E-ESE.
Dean Emery, Am. S. S.	do.	Balboa	17 08 N.	102 53 W.	27	6 a.	27	29.71	E	E, 10	ESE	E, 10	E-ESE.
Pennsylvania, Am. S. S.	New York	Los Angeles	22 35 N.	109 38 W.	25	4 p.	29	29.55	E	E, 9	E	E, 9	Steady.
Pres. Hayes, Am. S. S.	do.	San Francisco	22 05 N.	108 46 W.	30	7 1/2 a.	30	29.96	SSE	Calm	NW	NW, 12	E-C-N.

*Approximate position.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The weather changes on the North Pacific Ocean from August to September were generally such as might be expected to take place upon the near approach to autumn. The anticyclone west of the middle North American coast continued well developed, although more restricted in area than during August. The Aleutian low, which had not entirely disappeared on the average during any of the summer months, gained greatly in intensity, being central over the eastern Aleutians and the Peninsula of Alaska, with pressure lower than the normal for the month. Consequent upon the considerable increase in cyclonic activity along a great portion of the northern sailing routes, more frequent gales were experienced by steamships traversing this area than during any previous month since May. The wind forces in upper latitudes were not as a rule particularly high, however, and only one reported instance showed a force higher than 9. This was given by the American steamer *President Cleveland*, which encountered a WNW. gale of force 10 in 51° N., $177^{\circ} 30'$ W., early on the morning of the 5th.

A table of pressure data for several island and coast stations in west longitudes is given herewith. It should be noted that the average reading of 29.60 inches, for 26 days, at Dutch Harbor is too low for the month as a whole, since two of the missing p. m. observations are those of the 1st and 2d, during which days very high pressures overlay the Aleutians and Bering Sea.

TABLE 1.—Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, September, 1927

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Dutch Harbor ¹	29.60	-0.16	30.32	2d	28.02	25th
St. Paul ¹	29.78	+0.08	30.36	1st	29.18	25th
Kodiak ¹	29.69	-0.01	30.10	16th	29.02	25th
Midway Island ¹	29.94	-0.13	30.08	24th	29.74	9th
Honolulu ¹	29.95	-0.02	30.09	27th	29.86	16th
Juneau ¹	29.84	-0.08	30.47	18th	29.20	27th
Tatoosh Island ¹	29.94	-0.07	30.21	15th	29.49	27th
San Francisco ²	29.91	-0.08	30.12	4th	29.50	12th
San Diego ²	29.84	-0.04	30.01	23d	29.53	12th

¹ P. m. observations only.² For 26 days.³ For 28 days.⁴ For 29 days.⁵ A. m. and p. m. observations.⁶ Corrected to 24-hour mean.⁷ And on other dates.

If storms over the greater part of the ocean were comparatively unimportant, not so some of those of the Tropics, since several violent cyclones raged both in the Far East and off the Mexican west coast.

An account of the September typhoons is given on page 431. The only statement that may be added to that account is with reference to the typhoon mentioned in the concluding paragraph. A report received by the Weather Bureau from the British steamer *Tamaha* indicates this vessel to have been involved rather heavily in the storm off the coast of Japan, southwest of Yokohama, where for two days—the 27th and 28th—it encountered northeasterly squalls of hurricane force. This typhoon, according to the Japanese Weather Charts, advanced seaward during the 28th, and was immediately followed by a milder cyclone, which proceeded up the east coast of the archipelago on the 29th and 30th.

Three tropical cyclones, two of which were of major intensity, and the third exhibiting localized squalls of hurricane force, raged off the Mexican west coast during September.

The first developed apparently on the 6th somewhere near and to the southward of the Gulf of Tehuantepec, that stretch of water which is becoming known as a breeding place of tropical storms. It moved northwestward and by the morning of the 8th was central west of Manzanillo, giving frequent rain squalls of hurricane strength, as experienced by the British steamer *General Smuts*. On the 9th, the center was located west of Cape Corrientes, blowing a full hurricane. The American tanker, *D. G. Scofield*, reported a pressure of 29.15 inches, in $21^{\circ} 22'$ N., $108^{\circ} 27'$ W. Second Officer A. M. Larsen, of this vessel, said that at 2 p. m. of this date the wind was from the south, force 12. "The vessel was swept by a continuous blinding smother of rain and spray, through which the dim loom of the forecandle head could not be discerned from the bridge." On the 10th and the morning of the 11th strong gales to hurricane winds continued to prevail throughout the lower part of the Gulf of California from Cape Corrientes to above Mazatlan, and for a distance of a hundred or more miles to the westward of Cape San Lucas. During the 11th, however, the storm seems to have died out in the Gulf or broken up in the Cordilleras. Much damage was done to small shipping and some to larger craft; also to several of the coast towns and cities, and extraordinarily heavy accompanying rains and storm waves caused inundations, with consequent destruction to crops and houses, in addition to damage done by the winds. Quotations from a report to the Secretary of State by Mr. E. W. Eaton, American Vice Consul in Charge at Manzanillo, state:

The hurricane proper evidently passed to the west of Manzanillo some 100 or 200 miles at sea, as ships which were at sea in the vicinity of Cape San Lucas reported a wind 100 miles an hour with tremendously heavy seas. * * * The captain of the *Utecarbon* stated that he was in longitude 112.45° west and 23° north latitude when the storm was at its worst, during which time they had a wind of from 90 to 100 miles an hour and tremendously high seas for 36 hours. The captain stated that he had been going to sea for 26 years, but had never before encountered a storm equal to this one. The pilot house is 56 feet above the water line, yet a wave washed the captain and one of the mates away from the wheel in the chart room and from that time on he was compelled to steer the ship from the rear end.

The storm of the 11th and 12th seems to have been confined largely to the coast region between the western part of the Gulf of Tehuantepec and a point southeast of Manzanillo. Two or three southbound vessels reported escaping the hurricane to the northwestward only to encounter the further stormy weather of the closely following cyclone.

The third storm near the end was of utmost violence at sea. Signs of the disturbance were noticed south of the Gulf of Tehuantepec on the 25th, and on the following days, to and including the 30th, the storm moved up the coast, following very closely the track of the first. The full brunt of the hurricane was borne on the 30th by the American steamer *President Hayes*, J. J. Cadogan, master. This vessel, northward bound, entered the hurricane area with an ESE. wind and very rapidly falling pressure, in $22^{\circ} 02'$ N., $108^{\circ} 39'$ W., at 6 a. m. From 7:13 to 7:29 a. m. the steamer was unmanageable or until it entered the calm vortex, when it was nosed around to WSW. Pressure, meanwhile, between 7:00 and 7:29 a. m., had fallen the tremendous drop from 29.09 to 27.96 inches. The passage through the vortex occupied 31 minutes. To quote from the special report by Second Officer Niccols and Third Officer Phillips:

Approaching vortex of cyclone. Sea blown even, with solid sheet of spray, making it impossible to see a mast 30 feet away from the bridge. * * * Entered vortex with wind E. by S. Immediately encountered mountainous, confused sea, calm. Noticed

several species of birds and butterflies. * * * Air in vortex sultry, though no change was noticed in the dry bulb. Drumming in ears felt by nearly all observers. * * * Left vortex, taking approximately two minutes before encountering wind of maximum velocity, which was well over 125 miles per hour. Force of wind leveled the sea down; sheets of sea water and rain made visibility so poor that the sea alongside the vessel could not be distinguished from the bridge. * * * No green seas taken aboard. * * * At 9:30 a. m. weather had moderated sufficiently to enable vessel to hold her course and continue the voyage.

Hurricane velocities were experienced by the *President Hayes* until 8:35 a. m., by which time the pressure had risen to 29 inches. This barometric rebound, together with the preceding fall, constitutes the most rapid observed change in pressure of equal magnitude of which the writer has knowledge.

The accompanying table of gales and storms lists all vessels that have thus far sent tabular information of these Mexican hurricanes to the Weather Bureau.

At Honolulu the prevailing wind direction for September was east, and the maximum velocity was at the rate of 27 miles an hour from the east on the 7th.

At Tatoosh Island maximum velocities exceeding 60 miles an hour occurred as follows: 4th, 66 miles, from SW.; 18th, 64, E. The first occurred in connection with a strong development of the Aleutian cyclone in the Gulf of Alaska; the second, with a considerable pressure gradient existing between the oceanic anticyclone and a continental high to the northward.

Fog lessened greatly in occurrence since August, especially along the western half of the upper Pacific routes. The areas of most frequent observance were along the California coast south of the 40th parallel, where the percentage of occurrence ranged from 25 to 35; and over that part of the ocean bounded by the 45th and 50th parallels, 150th and 165th meridians of west longitude, where the percentage was about 30. Fog was noted southwest of the Bay of Panama on the 3d.

STRONG SOUTHWEST MONSOON

In a letter received from Lieut. B. C. Jackson (late R. N.) of the British steamship *Khosrou*, dated Karachi, August 24, 1927, appears the following statement:

I have had seven years experience on the Bombay, Red Sea, Persian Gulf, Bay of Bengal, and South Indian Ocean routes, and have never experienced a monsoon to compare with this year's between Aden and Colombo, especially in the vicinity of Socotra and Bombay, for heavy seas and high conspicuous swell, the wind keeping to the SW., instead of veering to the westward, as it generally does after clearing longitude of 55° E. All ships arriving in Bombay were reporting a bad passage across.

TYPHOONS AND DEPRESSIONS

FIVE TYPHOONS IN THE FAR EAST DURING SEPTEMBER, 1927

By REV. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

This month has been rather remarkable for the absence of typhoons, especially in the Philippines and Formosa. There was none in Formosa and only one in the Philippines, and even this one was not of a great extension and not very severe except in only one town in the eastern coast of Luzon.

In our article for last month we mentioned a typhoon which was shown by our weather maps of August 22 about 500 miles to the east of San Bernardino Strait and moved NW. by N. on the 22d and 23d; then we said that it moved very slowly for about four days to the east of northern Luzon and of the Balintang Channel, and that it seemed to be inclining again westward by the time we were writing such article. We may add here that the typhoon increased again its rate of progress on the 28th; that on

the 29th it inclined westward and traversed southern Formosa in the form of a shallow depression. But it passed near to the north of Pratas at 6 a. m. of the 30th and to the south of Hong Kong shortly after noon of the same day, moving WSW. or W. by S. It would seem, however, that after passing south of Hong Kong it inclined northwestward and struck the China coast west of the English Colony.

The Associated Press announced on September 26 that the Exchange Telegraph had received a report to the effect that 5,000 persons perished in Kwantung Province, when an immense tidal wave and typhoon struck the Chinese coast early in the month, 20,000 homes having been damaged and 400 junks and sampans destroyed, the loss being estimated at \$1,000,000. As there was no typhoon in that place at the beginning of September, we presume that the news refers to the last day of August, and that the typhoon was the one mentioned above.

The typhoon of Baler in central Luzon: September 17.—This typhoon was shown clearly for the first time on September 16, at 6 a. m. to the east of central Luzon, not far from 130° longitude E. and 15° latitude N. It moved rather rapidly to W. by N., and struck the eastern coast of Luzon during the night of the 17th, practically destroying the municipality of Baler. We have not received as yet any report from our observer at Baler, and so we can not give the barometric minimum observed at that station. Although the typhoon was much felt in the province of Pangasinan and the northern part of Nueva Ecija, yet it was not so severe as when it struck the eastern coast. The typhoon kept the same direction, W. by N., across the China Sea between Luzon and Indochina.

The approximate position of the center at 6 a. m. of the period September 17 to 20 was as follows:

September 17, 6 a. m., 125° 20' longitude E., 15° 15' latitude N.
September 18, 6 a. m., 119° 20' longitude E., 16° 20' latitude N.
September 19, 6 a. m., 115° 45' longitude E., 16° 55' latitude N.
September 20, 6 a. m., 110° 10' longitude E., 17° 30' latitude N.

Three typhoons between Bonins and Japan.—Typhoons appeared on our weather maps on August 25 and 26 about 300 miles west of the Ladrone Islands near 140° longitude E. and 15° latitude N. It moved northwest until the 29th, when it began to recurve northeastward near 130° longitude E. and 23° latitude N. On September 1 and 2 the typhoon was still moving northeastward to the SE. and E. of central Japan.

The second typhoon was shown in our weather maps of the 21st over 300 miles southwest of the Bonins and moved NE. and ENE. on the following days, 22d and 23d, passing north of the Bonins at about noon of the 23d.

The third typhoon was probably formed on the 26th to 27th east of the Loochoos, not far from 133° longitude E. and 25° latitude N. It moved northeastward on the following days, 27th to 30th, passing north of the Bonins on the 29th.

In connection with this typhoon we may mention a tornado that did considerable damage near the eastern boundary line of the city of Manila between 7 and 8 p. m. of September 17, when heavy thunderstorms were prevailing in Manila and near-by provinces. The tornado seems to have formed in the easternmost part of Pandacan, an eastern barrio of Manila, and to have moved mainly in a southeasterly or south-southeasterly direction toward San Felipe Nery, San Pedro Macati, and the Cemetery of Fort McKinley. The greatest damage was done to San Pedro Macati.

One typhoon over Japan, September 10 and 14.—This typhoon was of rather small diameter and could not be

TABLE 1.—Climatological data for Weather Bureau stations, September, 1927

Districts and stations	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind					Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month					
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Stations, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. mean min. +2	Departure from normal	Maximum	Minimum	Date	Mean maximum	Mean minimum	Date	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with .01 or more	Total movement	Prevailing direction	Maximum velocity									
																							Miles per hour	Direction				Date				
New England																																
	ft.	ft.	ft.	in.	in.	in.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	in.	in.		Miles											
Eastport	76	67	85	29.87	29.98	-0.8	56.4	+0.6	76	7	64	40	28	49	20	52	49	80	4.86	+1.9	8	5,069	s.	34	e.	2	8	8	14	5.3	0.0	0.0
Greenville, Me.	1,070	8	24	28.82	29.98	-0.4	56.0	...	75	2	66	30	28	46	39	52	49	80	2.39	-1.1	12	4,139	nw.	24	nw.	12	11	9	10	4.0	0.0	0.0
Portland, Me.	103	82	117	29.89	30.01	-0.04	61.4	+2.1	81	7	70	45	25	53	26	55	51	74	2.14	-1.1	9	5,719	sw.	25	nw.	11	14	11	5	4.4	0.0	0.0
Concord	280	70	79	29.69	30.00	-0.08	59.8	...	82	3	72	35	25	48	41	...	...	...	2.44	-0.8	7	2,931	nw.	20	nw.	11	16	5	9	4.1	0.0	0.0
Burlington	403	11	48	29.68	30.00	-0.06	59.7	-0.6	81	3	69	39	22	50	31	...	...	...	0.68	-2.7	7	4,419	s.	34	s.	30	9	10	11	5.8	0.0	0.0
Northfield	876	12	60	29.68	30.00	-0.03	58.5	...	80	3	69	32	22	44	43	53	51	90	1.57	-1.2	8	4,062	s.	23	s.	18	11	13	6	5.4	0.0	0.0
Boston	125	115	188	29.88	30.00	-0.07	65.0	+1.8	85	7	73	50	28	56	27	58	53	71	2.43	-0.8	5	5,050	sw.	28	ne.	1	14	11	5	4.7	0.0	0.0
Nantucket	12	14	90	30.00	30.00	-0.08	62.9	+0.1	76	4	69	49	29	57	17	59	57	84	2.58	-0.2	7	4,499	sw.	37	sw.	11	13	7	10	5.2	0.0	0.0
Block Island	26	11	46	29.98	30.01	-0.07	63.2	-0.2	77	4	68	52	25	58	17	59	58	85	2.56	-0.4	4	4,263	sw.	38	ne.	1	13	9	8	4.2	0.0	0.0
Providence	160	215	251	29.84	30.01	-0.06	64.3	+1.1	84	7	74	46	28	55	26	58	54	74	2.48	-0.7	6	4,553	nw.	36	nw.	11	15	7	8	4.2	0.0	0.0
Hartford	159	122	159	29.84	30.01	-0.06	64.2	+2.5	85	7	74	42	25	54	34	...	...	...	1.16	-2.3	4	...	s.	...	...	17	7	6	3.6	0.0	0.0	
New Haven	106	74	163	29.91	30.09	-0.05	65.0	+1.5	86	7	78	44	25	56	30	58	55	75	1.93	-1.9	5	5,438	sw.	34	ne.	1	13	12	5	4.2	0.0	0.0
Middle Atlantic States																																
							67.9	+1.1										78	2.04	-1.8												
Albany	97	100	115	29.91	30.01	-0.06	63.5	+0.4	84	7	73	44	22	54	27	58	56	83	1.57	-1.8	7	4,516	s.	26	s.	18	15	9	6	3.9	0.0	0.0
Binghamton	871	10	84	29.11	30.04	-0.03	62.8	+1.5	83	3	74	38	22	51	37	...	...	...	2.29	-0.5	6	3,130	e.	20	nw.	11	14	7	9	4.9	0.0	0.0
New York	314	414	454	29.69	30.02	-0.06	66.8	0.0	90	15	74	50	24	59	28	60	57	76	3.84	+0.2	5	5,266	sw.	50	nw.	1	11	13	6	4.0	0.0	0.0
Harrisburg	374	94	104	29.65	30.05	-0.03	66.8	+1.0	93	15	76	44	25	57	31	60	57	76	2.84	0.0	3	3,554	n.	25	w.	18	11	8	11	5.2	0.0	0.0
Philadelphia	114	120	182	29.92	30.04	-0.04	69.4	+1.4	96	15	78	51	24	61	31	62	59	73	2.59	-0.8	6	5,305	sw.	27	sw.	30	14	9	7	4.4	0.0	0.0
Reading	325	91	98	29.68	30.02	-0.07	67.4	...	95	15	78	43	25	57	31	60	58	73	2.08	+0.6	5	3,246	s.	25	se.	27	15	9	6	4.1	0.0	0.0
Scranton	805	111	119	29.19	30.04	-0.03	63.4	+0.5	90	15	75	39	24	52	35	58	56	85	1.45	-1.4	5	3,791	n.	23	sw.	30	12	7	11	5.0	0.0	0.0
Atlantic City	52	37	172	29.97	30.02	-0.05	67.5	+0.7	93	15	74	50	24	61	27	63	60	79	2.60	-0.4	7	9,430	s.	34	n.	1	18	5	7	3.7	0.0	0.0
Cape May	17	13	49	...	...	-0.05	68.6	-0.4	92	15	77	48	25	60	26	63	61	83	0.71	...	3	...	sw.	...	...	12	11	7	...	...	...
Sandy Hook	22	10	55	30.00	30.01	-0.05	67.2	...	98	15	74	54	25	61	24	61	58	76	3.16	...	4	8,894	sw.	47	n.	1	16	5	9	4.3	0.0	0.0
Trenton	190	150	183	29.82	30.02	-0.06	66.8	...	92	15	77	46	25	57	31	60	58	75	2.95	-1.6	5	5,942	sw.	34	sw.	30	13	11	6	4.5	0.0	0.0
Baltimore	123	100	215	29.90	30.03	-0.05	70.3	+1.8	97	15	80	48	25	61	30	63	58	70	1.93	-1.9	2	5,694	n.	27	w.	15	16	9	8	4.1	0.0	0.0
Washington	112	62	85	29.91	30.02	-0.06	70.1	+2.0	97	15	80	44	25	60	34	62	59	77	1.19	-2.4	8	3,116	s.	16	nw.	15	14	10	6	4.3	0.0	0.0
Cape Henry	18	8	54	30.00	30.02	-0.04	72.1	...	92	15	79	55	26	65	25	66	63	78	0.99	-3.1	7	7,436	sw.	39	n.	19	16	12	2	3.5	0.0	0.0
Lynchburg	681	153	188	29.31	30.04	-0.04	71.4	+2.4	94	15	83	42	25	60	35	63	60	78	0.31	-3.3	7	3,478	n.	23	n.	11	17	9	4	3.0	0.0	0.0
Norfolk	91	170	205	29.94	30.04	-0.02	73.2	+1.6	94	15	81	59	22	65	22	65	62	78	1.68	-2.4	5	6,700	s.	27	w.	3	15	11	4	3.9	0.0	0.0
Richmond	144	11	82	29.90	30.04	-0.03	70.6	-0.1	94	15	81	47	25	60	29	64	62	82	4.01	+0.6	5	4,000	sw.	21	sw.	30	20	9	1	2.7	0.0	0.0
Wytheville	2,304	40	55	27.72	30.05	-0.02	65.9	+2.3	90	10	78	36	23	54	32	59	56	80	1.21	-2.1	7	2,658	nw.	16	nw.	11	11	15	4	4.1	0.0	0.0
South Atlantic States																																
							73.4	+2.1										77	1.82	-2.8												
Asheville	2,253	70	84	27.74	30.05	-0.02	68.1	+3.1	90	17	79	39	24	57	30	60	58	80	1.14	-1.8	10	3,983	se.	26	n.	19	12	15	8	4.2	0.0	0.0
Charlotte	779	55	62	29.21	30.04	-0.03	74.5	+3.0	96	15	85	49	25	64	20	65	61	71	1.11	-2.1	5	2,408	ne.	15	nw.	19	7	22	1	4.8	0.0	0.0
Hatteras	11	11	50	30.01	30.02	-0.04	74.4	-0.1	85	14	80	63	13	69	17	60	66	77	1.17	-4.2	4	7,483	ne.	28	n.	24	12	14	1	4.0	0.0	0.0
Raleigh	376	103	110	29.94	30.03	-0.04	72.8	+1.7	85	15	83	49	24	63	26	60	63	75	3.82	+0.5	7	4,186	ne.	33	n.	1	15	11	4	3.9	0.0	0.0
Wilmington	78	81	91	29.95	30.05	-0.02	75.2	+2.1	85	14	84	55	25	67	22	60	67	85	3.35	-1.9	7	3,961	ne.	22	e.	9	14	14	2	4.2	0.0	0.0
Charleston	48	11	92	29.97	30.02	-0.02	78.1	+1.5	94	16	88	59	23	71	21	72	70	79	1.23	-4.2	3	5,736	ne.	35	ne.	25	19	10	1	3.0	0.0	0.0
Columbia, S. C.	351	41	57	29.96	30.03	-0.02	76.9	+2.4	97	15	87	50	24	67	25	67	68	71	2.64	-0.8	5	5,913	ne.	31	sw.	19	10	15	5	4.8	0.0	0.0
Due West	711	10	55	29.90	30.06	-0.05	75.6	...	98	17	86	49	25	65	25	...	...	...	2.18	...	4	4,686	ne.	24	ne.	22	13	16	1	4.2	0.0	0.0
Greenville, S. C.	1,039	139	146	29.96	30.03	-0.04	7																									

TABLE 1.—Climatological data for Weather Bureau stations, September, 1927—Continued

District and station	Elevation of instruments			Pressure		Temperature of the air										Precipitation			Wind				Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month					
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. +2	Mean min. -2	Departure from normal	Maximum	Date	Mean minimum	Minimum	Date	Mean maximum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with .01, or more							Total movement	Prevailing direction	Miles per hour	Direction	Date
Ohio Valley and Tennessee	ft.	ft.	ft.	in.	in.	in.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	in.	in.	in.	Miles										
Chattanooga	762	189	213	29.22	30.02	-.04	75.2	+3.0	98	17	89	48	23	64	29	64	68	1.03	-1.0	7	3,813	de.	36	sw.	3	12	17	1	3.7	0.0	0.0		
Knoxville	995	102	111	29.00	30.04	-.02	73.2	+2.6	96	16	85	44	23	62	30	65	62	0.78	-1.0	3	3,068	de.	21	s.	29	22	7	1	2.9	0.0	0.0		
Memphis	399	76	97	29.53	30.00	-.03	77.0	+3.4	97	16	86	48	22	69	25	67	63	1.45	-1.0	3	3,640	de.	38	sw.	18	15	9	6	4.3	0.0	0.0		
Nashville	546	168	191	29.45	30.04	-.02	74.8	+3.0	98	15	87	42	22	63	33	64	66	1.65	-2.0	6	4,901	nw.	39	nw.	9	11	13	6	4.6	0.0	0.0		
Lexington	989	193	230	29.99	30.04	-.03	72.2	+3.7	93	14	81	41	21	63	28	61	61	2.29	-0.1	2	7,020	sw.	47	sw.	29	14	10	6	3.6	0.0	0.0		
Louisville	525	188	234	29.46	30.03	-.03	73.5	+3.0	96	14	83	45	21	64	28	64	60	3.02	+0.4	3	5,643	sw.	46	s.	29	12	13	5	4.3	0.0	0.0		
Evansville	431	76	116	29.57	30.03	-.03	74.7	+4.0	96	16	84	44	21	65	28	66	61	4.74	+2.1	4	6,589	sw.	40	sw.	29	10	18	2	1.7	0.0	0.0		
Indianapolis	322	194	230	29.14	30.01	-.05	71.4	+4.5	96	16	81	43	21	62	28	62	65	2.70	-0.4	6	6,645	s.	31	s.	29	14	11	8	4.1	0.0	0.0		
Royal Center	736	11	55	29.21	30.00	-.05	68.4	—	96	15	80	37	21	67	30	63	65	4.83	—	9	5,678	w.	37	s.	29	13	9	8	5.2	0.0	0.0		
Terre Haute	875	96	128	29.28	29.99	-.04	72.4	—	96	15	82	41	21	62	28	63	66	4.59	—	8	5,423	sw.	36	w.	7	14	12	4	4.1	0.0	0.0		
Cincinnati	637	11	51	29.36	30.03	-.04	71.4	+4.3	95	15	83	40	21	60	36	62	68	3.28	+1.0	7	5,645	sw.	24	nw.	7	13	12	5	4.1	0.0	0.0		
Columbus	822	179	222	29.17	30.03	-.04	70.3	+3.8	95	16	80	41	21	60	36	62	68	2.06	-0.5	7	5,638	sw.	39	nw.	7	12	12	6	4.2	0.0	0.0		
Dayton	899	137	173	29.08	30.01	-.05	70.4	+3.8	94	15	81	41	21	60	36	61	66	2.82	+0.3	7	4,999	sw.	41	w.	7	13	12	5	4.6	0.0	0.0		
Elkins	1,947	59	67	28.05	30.03	-.00	63.8	+0.8	87	18	76	32	22	52	37	57	55	3.47	+0.6	7	2,346	nw.	18	nw.	18	7	17	6	5.6	0.0	0.0		
Parkersburg	637	77	82	29.40	30.05	-.03	70.0	+2.7	93	15	85	39	22	57	36	60	66	0.67	-2.0	6	2,713	de.	24	nw.	18	15	9	6	4.5	0.0	0.0		
Pittsburgh	842	353	410	29.14	30.03	-.05	68.1	+1.7	91	16	78	43	22	58	31	60	65	2.18	-0.3	7	5,629	w.	45	w.	18	8	14	8	4.8	0.0	0.0		
Lower Lake Region							65.6	+2.6										71	1.76	-1.0									4.6				
Buffalo	767	247	286	29.18	30.00	-.06	64.5	+2.1	82	15	73	45	21	67	32	58	54	1.08	-1.0	10	10,270	sw.	28	w.	20	12	12	6	4.8	0.0	0.0		
Canton	448	10	61	29.52	29.99	-.06	59.4	-0.1	80	3	70	37	9	49	38	56	53	1.68	-1.1	11	5,637	sw.	41	w.	30	11	13	6	4.8	0.0	0.0		
Oswego	335	76	91	29.52	30.00	-.06	62.4	+1.2	88	3	70	43	21	55	28	62	58	1.25	-1.0	8	5,662	sw.	33	n.	11	12	8	10	—	0.0	0.0		
Rochester	523	86	102	29.45	30.02	-.04	64.8	+2.4	84	7	74	41	24	56	31	67	52	0.51	-1.8	9	4,812	sw.	30	w.	30	10	12	8	5.2	0.0	0.0		
Syracuse	597	97	113	29.39	30.03	-.04	63.3	+1.7	84	30	73	46	21	63	30	61	57	1.63	-1.2	7	2,815	sw.	33	s.	28	11	11	8	5.0	0.0	0.0		
Erie	714	130	166	29.25	30.01	-.05	66.4	+2.8	84	7	74	43	24	58	28	59	54	1.92	-1.6	9	5,292	sw.	38	sw.	30	14	14	2	3.0	0.0	0.0		
Cleveland	762	190	201	29.20	30.01	-.05	67.6	+3.7	87	15	75	44	21	60	28	60	65	2.74	-0.5	12	7,992	sw.	37	w.	18	9	14	7	5.0	0.0	0.0		
Sandusky	629	65	67	29.34	30.01	-.05	68.6	+3.3	95	15	70	40	21	58	31	61	67	1.32	-1.4	7	5,617	sw.	31	sw.	30	9	12	9	5.1	0.0	0.0		
Toledo	628	208	243	29.33	30.01	-.05	68.4	+4.0	94	15	78	43	21	59	28	61	67	2.07	-0.3	7	8,484	sw.	47	sw.	30	16	7	7	4.0	0.0	0.0		
Fort Wayne	856	113	134	29.08	30.00	-.06	69.1	+3.6	95	15	70	39	21	59	34	60	60	3.12	—	9	5,617	sw.	30	s.	29	17	9	4	3.6	0.0	0.0		
Detroit	730	218	258	29.22	30.01	-.05	67.2	+3.7	95	15	70	43	21	59	24	60	60	3.44	+1.0	10	6,478	w.	40	sw.	30	9	14	7	5.2	0.0	0.0		
Upper Lake Region							62.7	+3.2										79	4.13	+0.9									5.9				
Alpena	609	13	92	29.31	29.08	-.05	60.2	+2.6	90	15	68	39	21	62	31	57	54	8.51	+2.0	17	7,466	de.	36	sw.	30	10	7	13	6.1	0.0	0.0		
Escanaba	612	54	60	29.20	29.95	-.06	59.7	+2.6	87	15	67	36	23	52	26	55	53	3.36	-1.2	16	6,393	sw.	30	n.	25	7	10	13	6.4	0.0	0.0		
Grand Haven	632	54	89	29.28	29.96	-.06	64.2	+2.3	88	14	72	43	21	55	26	56	50	7.70	+4.0	13	7,245	w.	43	w.	18	10	11	9	8.7	0.0	0.0		
Grand Rapids	707	70	87	29.21	29.97	-.06	67.2	+4.5	96	16	77	43	23	58	32	59	56	4.55	+1.4	17	3,522	w.	26	nw.	18	6	8	16	6.9	0.0	0.0		
Houghton	668	64	99	29.22	29.94	-.06	59.6	+2.7	94	14	66	37	25	53	31	53	53	3.93	-0.4	18	6,992	sw.	36	w.	18	7	7	16	6.7	0.0	0.0		
Lansing	878	11	62	29.05	30.01	-.05	65.4	+4.0	94	13	77	38	23	64	40	59	50	4.67	+2.0	13	3,289	w.	25	s.	29	13	9	8	4.6	0.0	0.0		
Ludington	637	60	66	29.26	29.96	-.06	62.4	—	82	14	69	40	24	56	23	58	50	5.58	—	15	7,200	w.	46	sw.	30	12	8	10	4.9	0.0	0.0		
Marquette	734	77	111	29.15	29.94	-.06	60.8	+3.3	95	14	69	40	23	54	31	55	51	7.20	-1.3	16	6,356	w.	36	w.	18	7	8	18	7.0	0.0	0.0		
Port Huron	638	70	130	29.30	29.99	-.07	64.7	+1.1	92	15	74	39	21	60	28	59	50	7.25	-0.2	11	6,844	sw.	36	s.	29	11	13	6	4.4	0.0	0.0		
Sault Sainte Marie	614	11	82	29.28	29.97	-.06	63.6	+3.1	92	2	67	37	26	60	31	54	52	3.80	+0.3	16	4												

TABLE 1.—Climatological data for Weather Bureau stations, September, 1927—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind			Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month					
	Barometer above sea level	Thermometer above ground	Thermometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. +2	Mean min. -2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.1 or more							Total movement	Prevailing direction	Maximum velocity		
																															Miles per hour	Direction	Date
Northern Slope																																	
Billings	3,140	5	44	27.36	29.92	-0.02	57.2	-1.3	92	3	73	27	20	42	49	47	40	63	0.72	7	7	nw.	27	sw.	11	7	13	8	5.8	0.0	0.0		
Havre	2,505	11	44	25.70	29.92	-0.05	54.4	-2.2	85	6	66	34	15	43	39	40	30	63	0.55	-0.5	10	5,465	sw.	46	sw.	6	8	8	14	6.0	0.0	0.0	
Helena	4,110	87	112	25.70	29.92	-0.05	54.4	-2.2	85	6	66	34	15	43	39	40	30	63	0.55	-0.5	10	5,465	sw.	46	sw.	6	8	8	14	6.0	0.0	0.0	
Kalispell	2,973	48	56	28.88	29.91	-0.05	52.9	-0.6	78	21	63	34	16	43	32	40	49	71	2.70	+1.4	13	3,585	nw.	22	sw.	6	8	9	13	5.0	0.0	0.0	
Miles City	2,371	48	55	28.98	29.96	-0.01	58.4	-2.8	99	0	71	24	20	46	39	66	1.80	+0.9	8	1.82	nw.	36	nw.	12	15	8	12	5.0	0.0	0.0			
Rapid City	3,259	50	58	26.88	29.97	-0.01	58.8	-1.6	90	4	70	24	27	47	28	49	43	61	1.80	+0.5	8	5,060	w.	35	w	14	12	8	10	5.0	4.8	0.0	
Cheyenne	6,088	84	101	24.02	29.91	-0.05	56.2	-0.8	81	10	68	23	26	44	36	45	38	60	1.03	+0.1	5	8,698	w	45	w	13	9	12	9	5.1	1.0	0.0	
Lander	5,372	60	63	24.63	29.92	-0.04	55.0	-0.7	85	3	68	30	27	42	39	45	37	58	3.15	+2.1	6	3,793	sw.	32	w	7	11	10	9	5.0	T	T	
Sheridan	3,790	10	47	26.06	29.94	-0.03	55.4	-0.8	91	10	71	28	27	40	48	47	42	71	1.81	-1.4	13	2,887	nw.	22	se.	12	13	10	7	4.8	T	0.0	
Yellowstone Park	6,241	11	49	23.86	29.94	-0.03	48.6	-4.8	77	3	60	30	19	37	28	41	35	67	2.36	+1.4	13	5,397	s	38	s	6	9	12	9	5.6	T	0.0	
North Platte	2,821	11	51	27.04	29.93	-0.01	55.2	+3.1	94	1	70	31	27	51	44	54	48	67	3.16	+1.6	8	4,865	s	29	s	18	10	7	4	3.3	0.2	0.0	
Middle Slope																																	
Denver	5,222	106	113	24.73	29.92	-0.04	62.0	-0.9	86	10	74	23	26	50	32	50	42	50	1.06	+0.2	8	4,318	s	37	nw.	23	12	13	5	4.0	1.7	0.0	
Pueblo	4,685	80	80	25.27	29.89	-0.07	63.7	-0.9	90	10	78	33	27	50	39	50	42	52	1.16	+0.6	8	4,375	nw.	33	w	29	11	14	8	4.4	T	0.0	
Concordia	1,392	50	59	23.43	29.94	-0.03	69.0	+0.7	94	17	79	36	21	59	36	60	56	71	1.55	-1.0	10	5,548	s	31	n	29	10	8	6	4.1	0.0	0.0	
Dodge City	2,509	11	51	27.39	29.95	-0.03	69.0	-0.4	93	3	81	36	26	57	28	58	54	68	2.77	+1.0	6	7,125	sw.	33	ne.	1	21	3	6	3.2	0.0	0.0	
Wichita	1,358	136	158	28.53	29.94	-0.06	71.0	+0.4	93	17	80	38	28	62	32	62	58	71	3.93	+0.8	8	9,190	s	32	s	29	16	4	10	4.6	0.0	0.0	
Broken Arrow	765	11	56	29.16	29.98	-0.04	72.0	-0.7	93	17	82	42	21	62	33	64	60	70	3.64	+0.9	8	7,375	s	30	s	29	16	4	10	4.6	0.0	0.0	
Oklahoma City	1,214	10	47	28.69	29.95	-0.04	73.8	+1.0	94	16	84	43	27	63	31	64	60	70	3.63	+0.9	8	7,029	s	32	s	30	10	10	7	4.7	0.0	0.0	
Southern Slope																																	
Abilene	1,738	10	52	28.15	29.92	-0.04	76.2	+0.9	103	1	87	46	27	60	31	64	60	66	5.89	+2.8	8	6,409	s	42	sw.	2	11	8	11	4.0	0.0	0.0	
Amarillo	3,676	10	49	26.27	29.94	-0.02	68.2	-1.1	91	7	80	36	27	57	39	58	54	70	3.40	+1.0	11	6,961	s	36	s	12	14	10	6	4.2	0.0	0.0	
Del Rio	944	64	71	28.90	29.86	-0.08	81.2	+2.0	101	1	90	50	28	72	24	70	65	94	0.63	-1.9	6	7,426	se.	38	e	6	11	9	10	5.1	0.0	0.0	
Roswell	5,566	73	85	20.33	29.87	-0.05	71.1	+1.0	91	2	84	43	27	56	42	58	51	70	0.17	-1.6	6	5,498	s	32	n	15	13	15	2	3.8	0.0	0.0	
Southern Plateau																																	
El Paso	3,778	152	178	26.13	29.82	-0.06	75.0	+1.7	92	8	87	56	27	64	30	60	52	50	1.04	-0.4	6	6,590	e.	30	w	30	17	13	0	2.9	0.0	0.0	
Santa Fe	7,013	38	53	23.20	29.86	-0.07	66.0	-0.3	70	1	71	35	28	50	31	50	45	60	2.23	+0.6	13	3,819	se.	25	ne.	6	10	11	9	5.1	0.0	0.0	
Flagstaff	6,907	10	50	23.37	29.83	-0.07	66.2	-0.7	77	30	69	27	30	43	37	48	45	71	4.02	-0.2	11	5,480	sw.	32	s	13	7	18	5	4.0	0.0	0.0	
Phoenix	1,108	10	52	24.61	29.79	-0.06	82.0	-0.1	104	4	96	55	27	70	37	60	57	48	0.83	-0.2	6	3,461	e.	30	e	6	10	10	1	2.8	0.0	0.0	
Yuma	141	9	54	29.59	29.72	-0.06	83.0	-0.1	108	5	99	57	28	69	41	60	56	47	0.00	-0.2	3	3,591	sw.	30	se.	12	24	6	0	1.6	0.0	0.0	
Independence	3,957	5	25	25.09	29.82	-0.04	66.2	-1.8	93	19	84	42	18	49	43	50	45	61	0.40	+0.3	3		n.			22	6	2		0.0	0.0		
Middle Plateau																																	
Reno	4,532	74	81	25.42	29.87	-0.03	57.8	-1.9	90	19	73	31	14	43	29	45	34	47	0.11	-0.2	3	4,662	w.	35	w	23	21	7	2	2.7	0.0	0.0	
Tonopah	6,090	12	20	26.20	29.84	-0.03	59.4	-0.3	70	1	71	30	23	40	23	44	29	34	0.13	-0.1	2		nw.			20	12	15	3	4.1	0.0	0.0	
Winnemucca	4,444	18	50	25.59	29.94	-0.01	56.0	-0.4	92	20	79	23	14	39	47	43	35	59	0.21	-0.1	4	4,807	sw.	40	w	20	12	15	3	4.1	0.0	0.0	
Modena	5,473	10	43	24.56	29.81	-0.11	59.6	-0.4	85	20	74	34	29	45	41	47	34	46	1.40	+0.3	5	8,045	sw.	52	s	9	19	11	0	2.2	0.0	0.0	
Salt Lake City	4,300	163	203	25.54	29.85	-0.10	63.2	-1.2	89	3	74	36	30	52	31	50	40	49	2.08	+1.3	10	5,113	nw.	38	se.	6	16	6	8	4.0	T	0.0	
Grand Junction	4,602	60	68	25.34	29.88	-0.07	65.3	-0.9	90	3	77	36	29	53	42	53	45	58	3.29	+2.3	15	4,806	se.	44	s	8	12	12	6	4.4	0.0	0.0	
Northern Plateau																																	
Baker	3,471	48	53	26.41	29.98	-0.01	53.0	-3.0	81	20	64	29	8	42	38	46	40	67	2.07	+1.3	15	3,674	se.	24	s	3	9	6	15	6.0	0.0	0.0	
Boise	2,739	78	86	27.10	29.94	-0.03	59.6	-2.3	87	5	72	34	8	47	38	50	42	58	1.39	+1.0	10	3,287	se.	33	w	27	13	6	11	4.8	0.0	0.0	
Lewiston	757	40	48	29.11	29.92	-0.06	60.0	-2.2	85	2	71	41	7	50	40	46	35	49	1.88	+0.7	9	3,348	se.	40	sw.	6	11	7	12	4.9	0.0	0.0	
Pocatello	4,477	60	68	25.41	29.88	-0.05	58.2	-2.0	89	3	72	38	15	45	40	46	35	49	1.88	+0.7	9	3,348	se.	40	sw.	6	11	7	12	4.9	0.0	0.0	
Spokane	1,939	101	110	27.90	29.93	-0.03	57.4	-1.8	79	21	66	33	15	48	31	50	45	68	5.58	+4.8	10	2,986	s	23	sw.	28	5	9	16	6.5	0.0	0.0	
Walla Walla	901	57	65	28.88	29.94	-0.06	60.7	-3.1	82	20	70	41	8	52	30	53	47	65	4.50	+3.6	13	3,123	s	18	sw.	28	7	10	13	6.2	0.0	0.0	
North Pacific Coast Region																																	
North Head	211	11	56	29.78	29.98	-0.05	57.5	+1.0	83	17	61	46	15	54	29	55	53	83	3.22	+0.7	10	10,833	n.	62	s	27	3	6	21	8.0	0.0	0.0	
Port Angeles	29	8	50	29.90	29.90	-0.05	55.0	-0.7	77	19	63	42	8	48	28	54	51	77	1.72	-0.1	11	3,790	sw.	28	w	29	4	13	13	0.0	0.0	0.0	
Seattle	125	215	250	29.82	29.86	-0.05	58.7	+0.6	81	19	65	47	8	52	25	64	51	77	2.73	+1.0	13	5,920	s	32	s	5	5	5	20	7.2	0.0	0.0	
Tacoma	194	172	201	29.78	29.86	-0.04	58.7	+0.6	82	19	66	46	8	52	24	63	52	68	3.10	+1.0	15	5,517	s	37	sw.	11	3	7	20	7.3	0.0	0.0	
Tatoosh Island	86	9	53	29.85	29.94	-0.07	56.2	+3.2	76	18	60	48	23	52	24	63</																	

TABLE 2.—Data furnished by the Canadian Meteorological Service, September, 1927

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Depart- ure from normal	Mean max. + mean min. +3	Depart- ure from normal	Mean maxi- mum	Mean mini- mum	Highest	Lowest	Total	Depart- ure from normal	Total snowfall
	Feet	In.	In.	In.	° F.	° F.	° F.	° F.	° F.	° F.	In.	In.	In.
Cape Race, N. F.	90				52.5		50.4	45.7	71	38	3.11		0.0
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20	29.88	29.90	-.08	51.0	+0.6	58.2	43.9	73	28	3.04	-0.09	0.0
Quebec, Que.	296	29.64	29.96	-.05	50.9	+1.8	65.2	48.6	76	40	2.26	-1.42	0.0
Doucet, Que.	1,236												
Montreal, Que.	187	29.76	29.96	-.08	60.0	+1.5	67.7	52.3	80	44	2.52	-0.78	0.0
Ottawa, Ont.	236	29.73	29.90	-.05	60.7	+3.3	71.7	49.7	84	38	1.25	-1.44	0.0
Kingston, Ont.	235	29.69	30.00	-.04	61.2	+1.2	68.6	53.9	76	40	2.43	-0.37	0.0
Toronto, Ont.	379	29.59	29.99	-.07	63.3	+4.3	73.0	53.7	88	39	1.11	-2.14	0.0
Cochrane, Ont.	930												
White River, Ont.	1,344	28.60	29.91	-.07	53.3	+2.0	64.3	40.4	81	16	3.01	+0.24	0.0
London, Ont.	808				64.4		76.4	52.4	90	32	2.80		0.0
Southampton, Ont.	456	29.27	29.98	-.07	61.1	+3.6	70.1	52.1	82	41	3.91	+0.97	0.0
Perry Sound, Ont.	488	29.28	29.96	-.07	59.6	+3.6	68.3	51.0	79	40	3.61	-0.06	0.0
Fort Arthur, Ont.	644	29.23	29.94	-.04	58.8	+6.6	67.1	50.6	88	38	3.44	-0.04	0.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.11	29.91	-.03	53.1	+2.6	62.8	48.5	84	20	1.08	-0.28	0.5
Le Pas, Man.	860				52.8		63.2	42.5	82	23	3.38		0.5
Qu'Appelle, Sask.	2,115	27.64	29.87	-.05	51.9	+0.8	62.4	41.5	84	20	5.94	+4.61	2.8
Moose Jaw, Sask.	1,759				54.7		67.7	41.8	91	18	1.88		0.0
Swift Current, Sask.	2,392	27.34	29.84	-.05	54.3	+1.2	68.3	40.3	90	21	1.67	+0.45	0.4
Medicine Hat, Alb.	2,144	27.58	29.83	-.09	55.3	+0.3	66.7	44.0	82	30	1.65	+0.47	T.
Calgary, Alb.	3,428	26.37	29.93	+0.01	50.5	+0.7	62.2	38.9	78	27	4.36	+3.00	T.
Banff, Alb.	4,521	25.35	29.90	-.03	46.6	+0.8	57.8	35.5	71	25	2.32	+0.65	0.0
Prince Albert, Sask.	1,450	28.33	29.90	-.00	51.8	+3.4	62.7	41.0	86	22	4.37	+3.09	3.9
Battleford, Sask.	1,592	28.13	29.85	-.03	52.7	+0.9	64.8	40.6	89	25	1.71	+0.46	0.2
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262	28.64	29.92	-.05	58.6	+1.2	67.7	49.5	76	40	1.50	+0.65	0.0
Victoria, B. C.	230	29.70	29.95	-.06	56.9	+2.1	63.8	51.0	78	47	1.95	-0.21	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.86	30.02	-.03	79.0	+1.6	86.0	72.1	90	68	3.72	-2.79	0.0

LATE REPORTS, AUGUST, 1927

Cape Race, N. F.	90				50.1		67.6	50.5	73	42	2.15		0.0
Sydney, C. B. I.	48	29.98	30.03	+0.05	64.8	+1.5	74.0	55.6	80	46	5.88	+2.26	0.0
Halifax, N. S.	88	29.76	29.86	-.10	62.0	-1.6	69.1	55.0	74	49	7.57	+3.22	0.0
Yarmouth, N. S.	65	29.88	29.95	-.02	60.7	+0.5	67.7	53.7	77	47	9.92	+6.30	0.0
Charlottetown, P. E. I.	38	29.92	29.96	+0.02	65.5	+1.2	72.2	58.8	78	52	5.41	+1.67	0.0
Chatham, N. B.	28	29.86	29.89	-.04	62.4	-0.8	73.4	51.4	80	40	5.82	+1.73	0.0
Winnipeg, Man.	760	29.18	30.01	+0.07	63.3	-0.1	74.7	51.9	88	36	2.85	+0.13	0.0

Chart I. Tracks of Centers of Anticyclones, September, 1927. (Inset) Departure of Monthly Mean Pressure from Normal (Plotted by Wilfred P. Day)



Chart II. Tracks of Centers of Cyclones, September, 1927. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Wilfred P. Day)

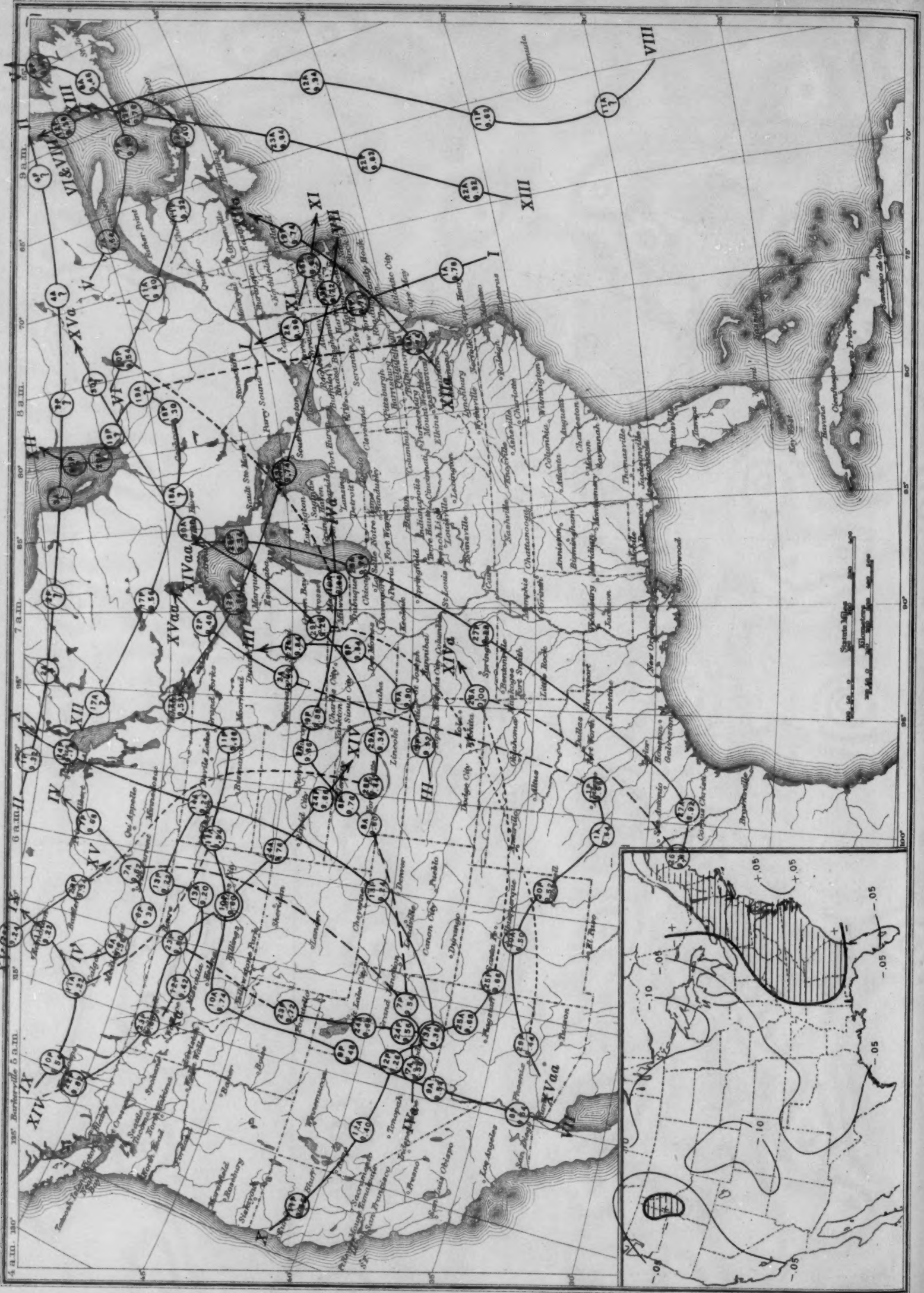


Chart III. Departure ($^{\circ}\text{F.}$) of the Mean Temperature from the Normal, September, 1927

Chart III. Departure (°F.) of the Mean Temperature from the Normal, September, 1927



Chart IV. Total Precipitation, Inches, September, 1927. (Inset) Departure of Precipitation from Normal

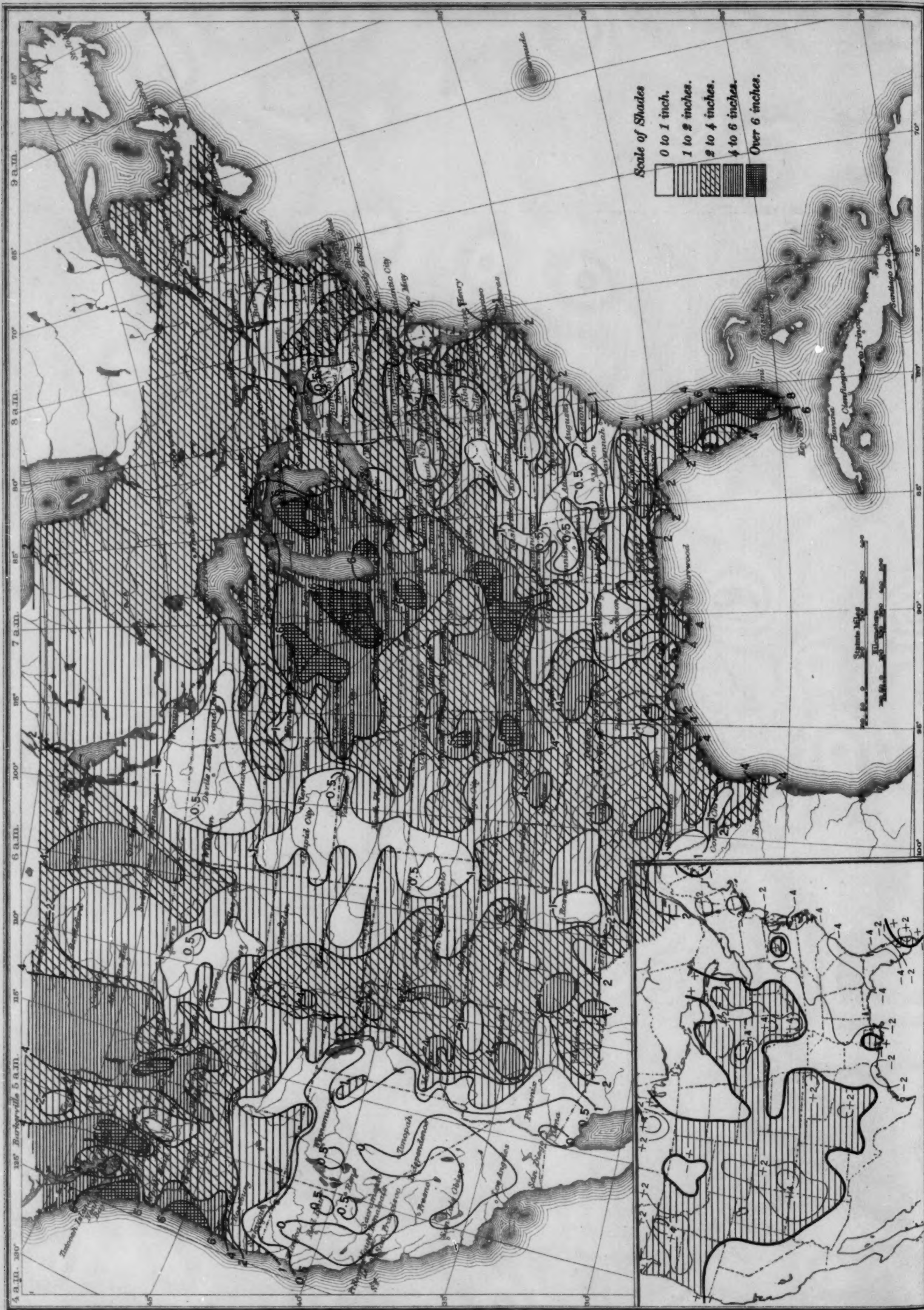


Chart V. Percentage of Clear Sky between Sunrise and Sunset, September, 1927

Chart V. Percentage of Clear Sky between Sunrise and Sunset, September, 1927



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Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, September, 1927

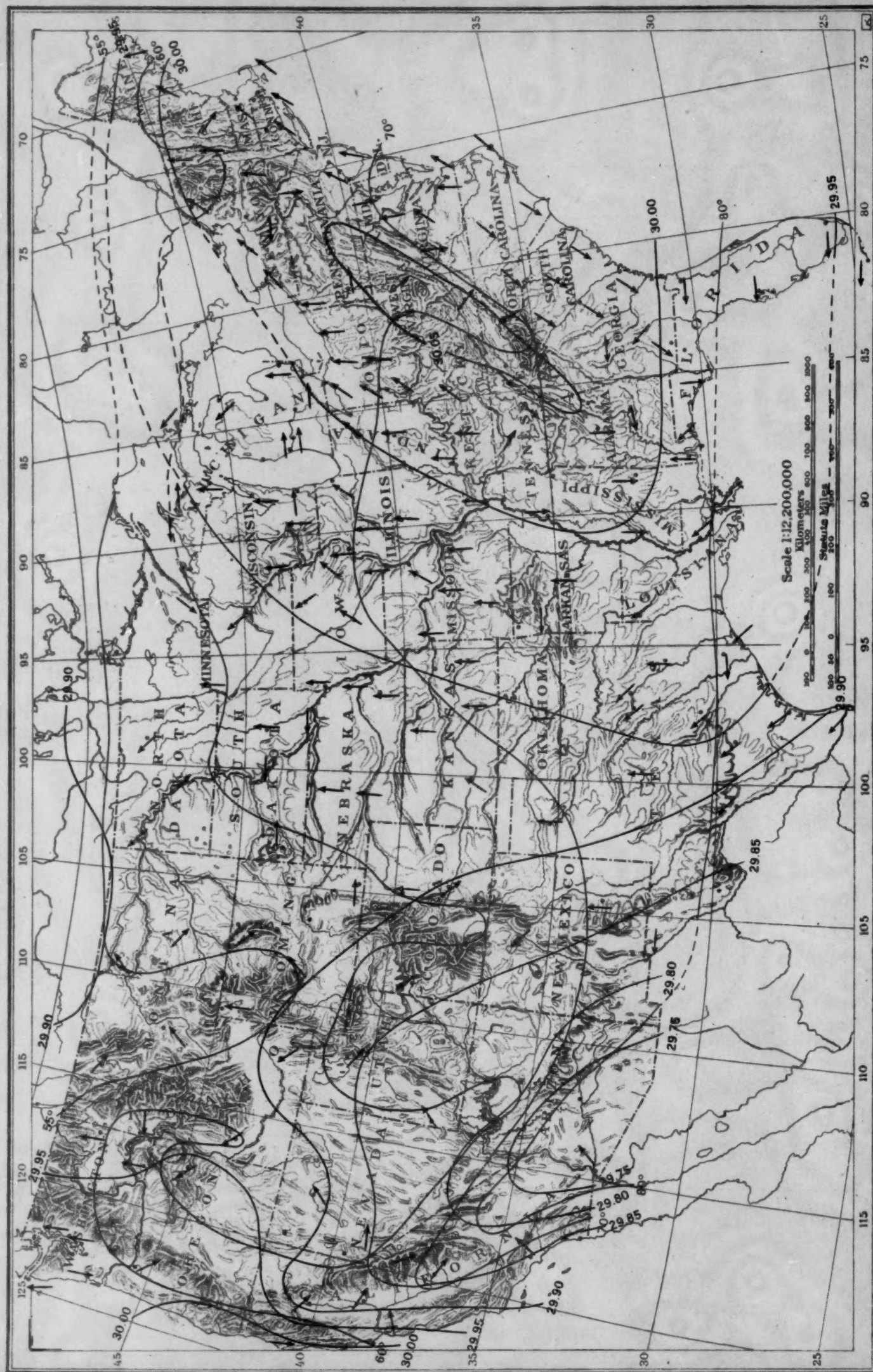
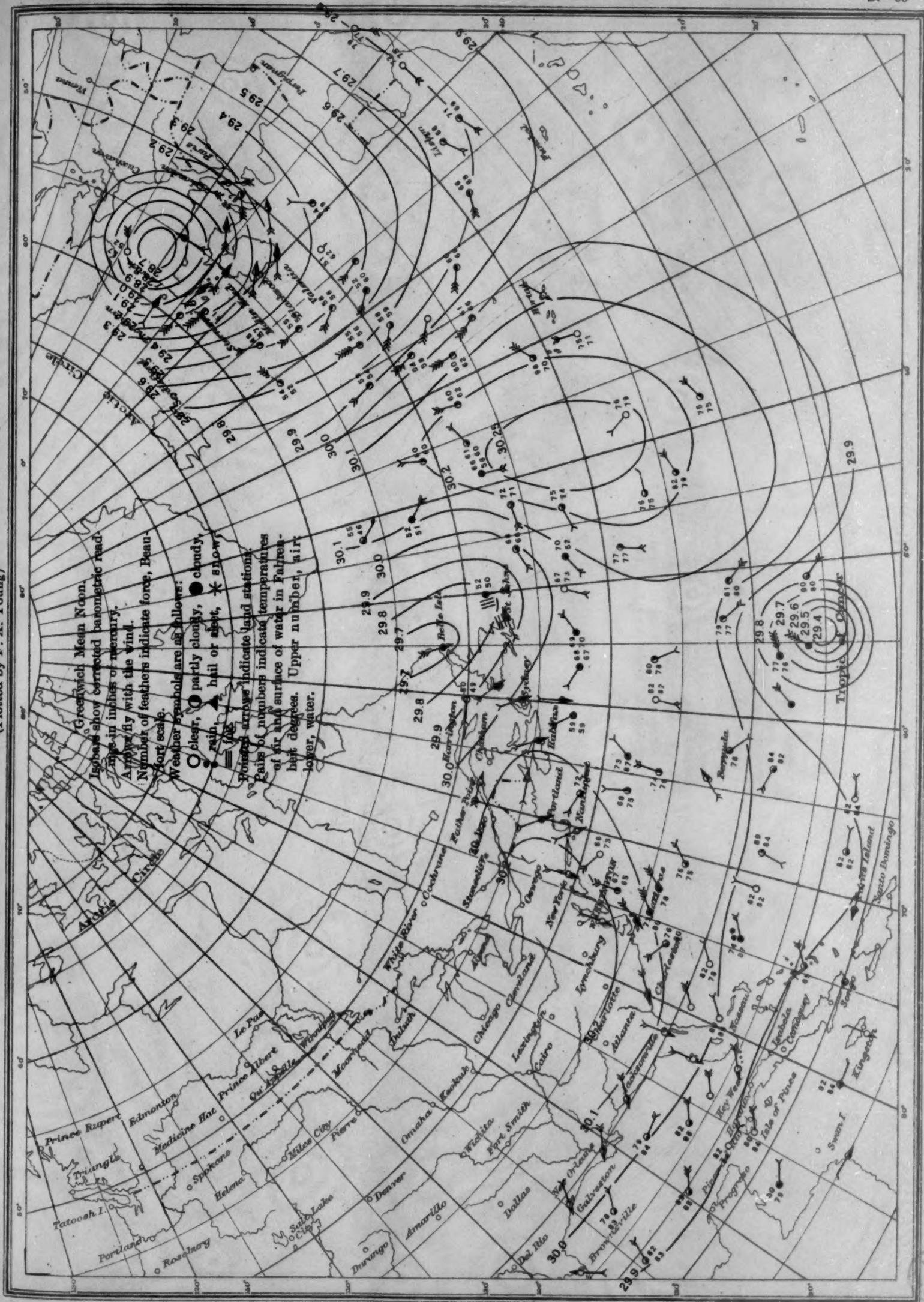


Chart VIII. Weather Map of North Atlantic Ocean, September 24, 1927
(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, September 24, 1927
(Plotted by F. A. Young)



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Chart IX. Weather Map of North Atlantic Ocean, September 25, 1927
(Plotted by F. A. Young)

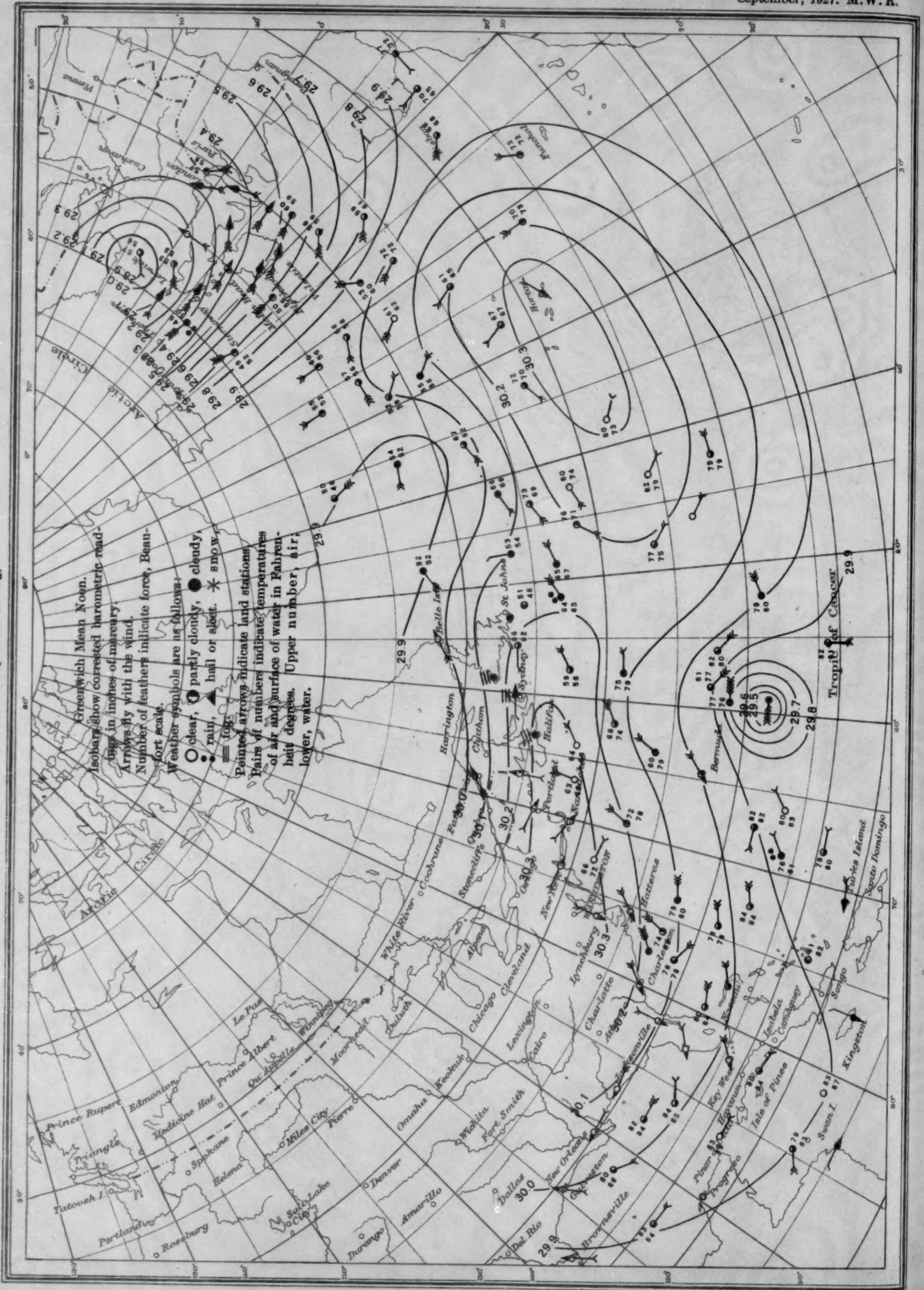


Chart X. Weather Map of North Atlantic Ocean, September 26, 1927
(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, September 26, 1927
(Plotted by F. A. Young)

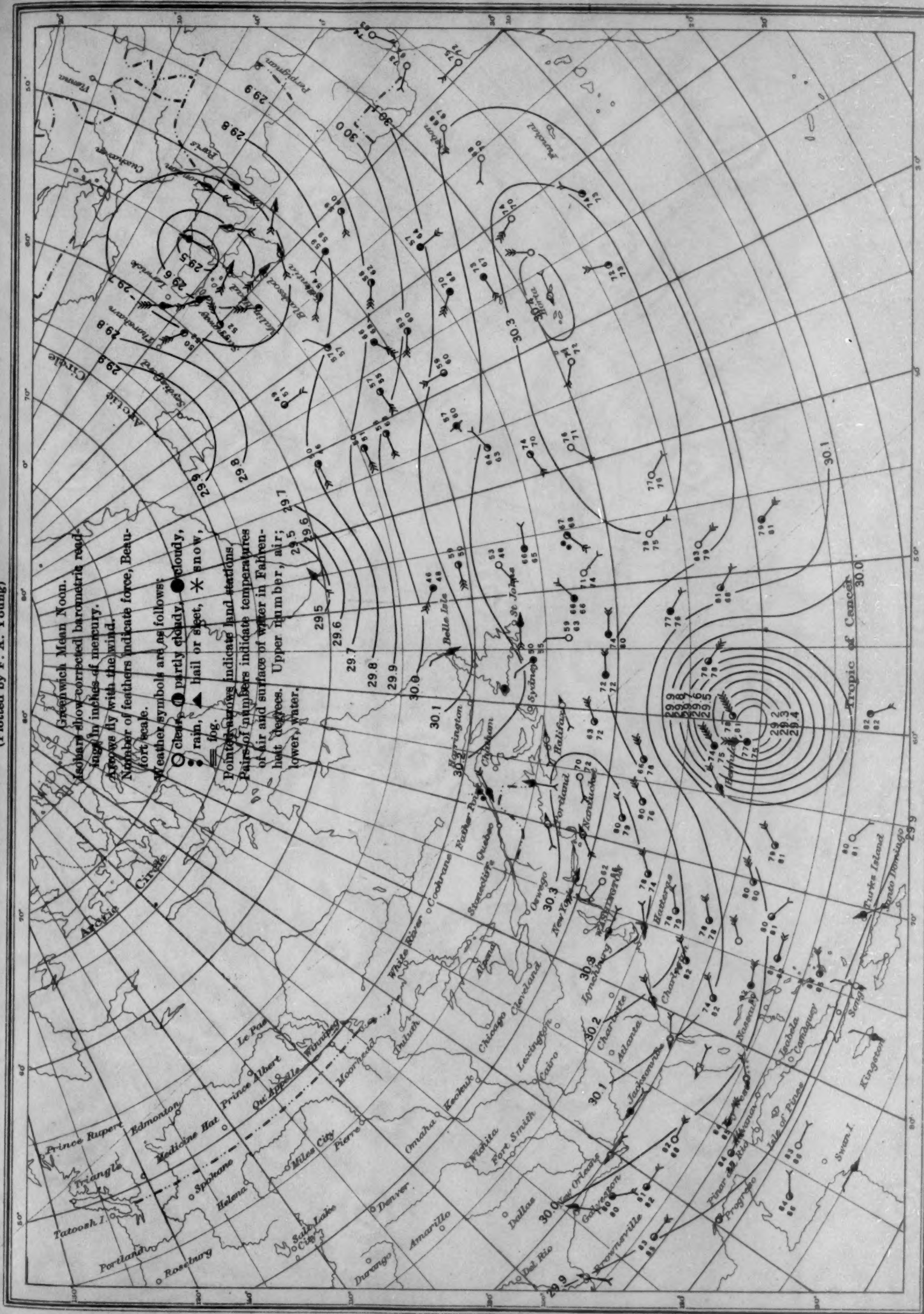


Chart XI. Weather Map of North Atlantic Ocean, September 27, 1927
(Plotted by F. A. Young)

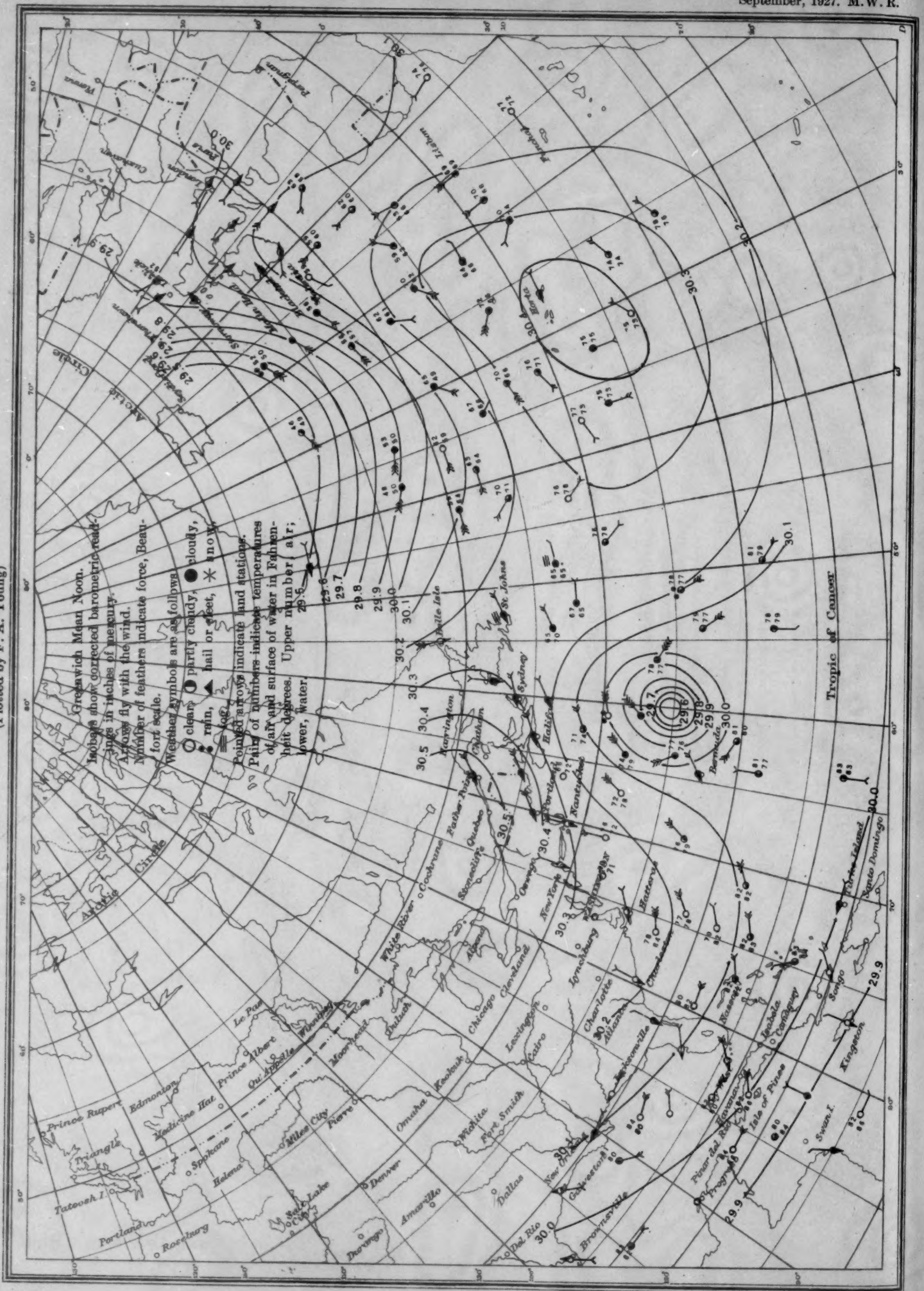


Chart XII. Weather Map of North Atlantic Ocean, September 28, 1927
(Plotted by F. A. Young)

Chart XII. Weather Map of North Atlantic Ocean, September 28, 1927
(Plotted by F. A. Young)

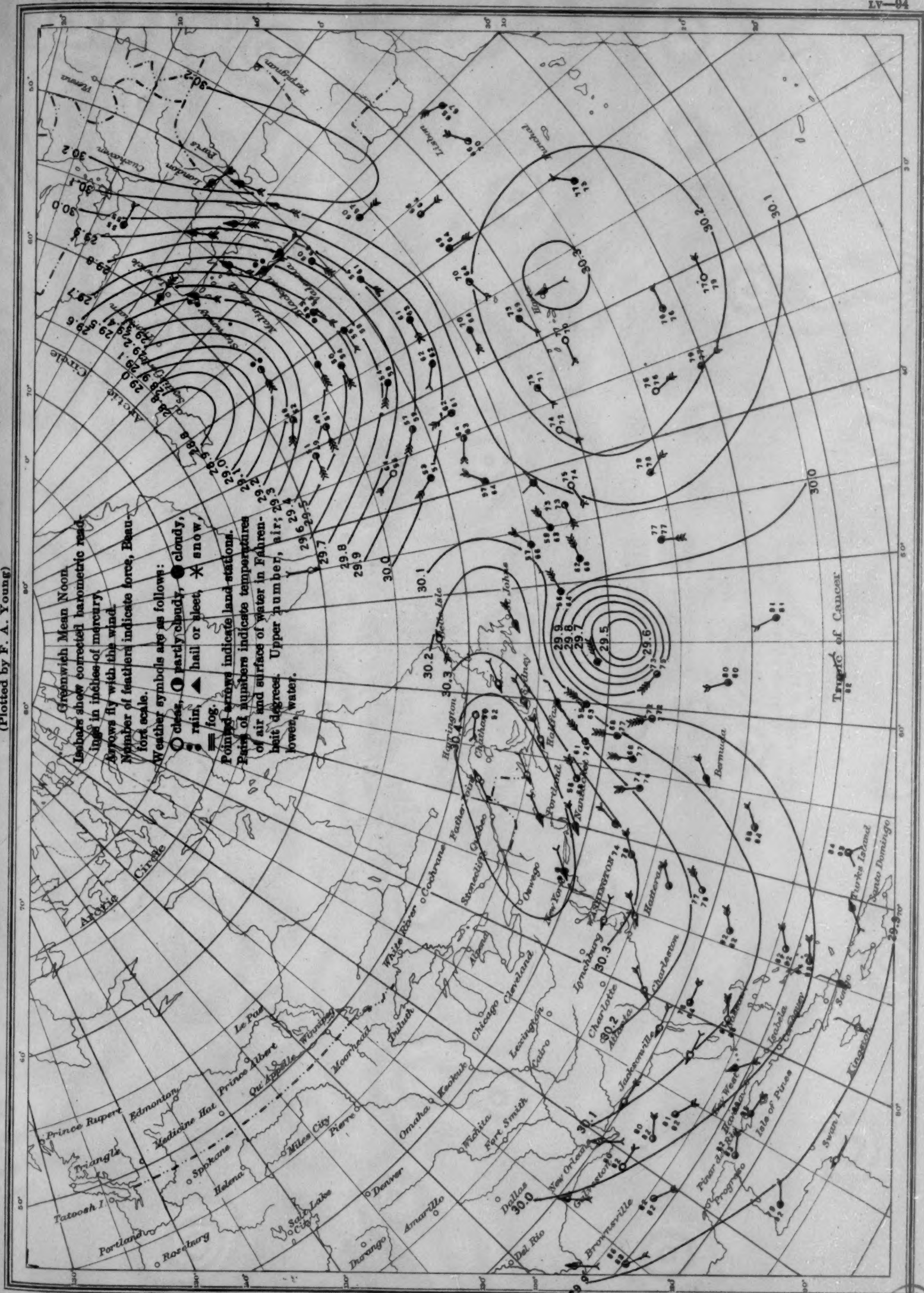


Chart XIII. Weather Map of North Atlantic Ocean, September 29, 1927
(Plotted by F. A. Young)

